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TECHNICAL DEVELOPMENT OF RADIOLOGY*
1906–1956

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IN THE year 1906 the roentgen rays were about ten years old and the young science of radiology counted many enthusiastic workers among its disciples. But even the most enthusiastic ones could hardly foresee the tremendous strides that the technical developments of radiology were to take during the subsequent fifty years.

High-Voltage Generators. In 1906 the high voltage for the production of roentgen rays was obtained from two types of generators, the static machine and the induction coil. The static machines were of the Toepler-Holtz type and were produced by a number of manufacturers, among them Waite & Bartlett, Van Houten-Ten Broek, McIntosh, Pattee-Jerman, Birtman, Harvard, Betz, Wagner Mica Plate, and Nelson and Baker. The average static machine produced voltages up to 100 kilovolts with a current capacity of about 1 milliampere. Although their unidirectional current was ideal for diagnostic tubes, the low current output necessitated long exposure times and for this reason they primarily were used for therapy. Some of the static machines were of gigantic proportions with glass plates as large as 6 feet in diameter or with batteries of as many as 50 revolving glass plates. However, static machines had definite disadvantages in addition to the low current output: they were fragile, their operation depended a good deal upon atmospheric conditions, and they lacked voltage and milliamperage control.

Because of those disadvantages, induction coils had begun to replace the static machines in 1906. The roentgen-ray induction coils were patterned after those used in physical laboratories and were of the type that Röntgen was using when he discovered the roentgen rays, only larger. After early difficulties, consisting mainly in breakdowns of the insulation between primary and secondary, were overcome, reliable induction coils producing spark-over voltages from 6 to 12 inches were commercially produced by Campbell, Kelley-Koett, Kinraide, Myer, Queen, Scheidel-Western, Snook, Victor-Wantz, Vulcan, and Willyoung. The most powerful coils produced voltages approaching 200 kilovolts and cur-

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rents up to 20 milliamperes. These energies exceeded by far the capacities of roentgen-ray tubes of those days.

One of the great drawbacks of the early induction coils, and even those of 1906, was that the direct current which was obtained from batteries and was fed into the primary of the induction coil, had to be continuously interrupted. Mechanical or electromagnetic interrupters initially were used, but they were noisy and their contact points were quickly pitted and burned with consequent changes in the regularity of the energy output of the coil. Mercury-jet and plunger-type interrupters were an improvement over the mechanical type because they operated quietly and permitted a higher current input, but unfortunately they had to be cleaned too frequently. Around 1906 the Wehnelt electrolytic interrupter came into more general practical use. It improved the regularity of the current and permitted a higher current input. However, with prolonged use the electrolytic interrupter became heated and emitted disagreeable acid fumes. It, therefore, was infrequently used for fluoroscopy or for therapy.

This then was the picture of the high-voltage generator in 1906: Static machines and induction coils were used for both diagnostic and therapeutic work, and they were capable of producing higher voltages and currents than the gas tubes at that time could stand. However, even at their best, the high-voltage currents produced with these machines fluctuated widely and reproduction of output from day to day was difficult to attain.

The next improvement in the construction of high-voltage generators came one year later in October of 1907, when the "Snook Interrupterless Transformer" was demonstrated at the Cincinnati meeting of the American Roentgen Ray Society. This transformer was a closed magnetic circuit and alternating current was fed into the primary. To obtain a unidirectional secondary current, Snook used a rotating crossarm rectifying switch in the secondary of this transformer, which was operated by a synchronous motor and which cut out the undesired reverse phase of the current. The apparatus produced larger roentgen-ray energy outputs and permitted much better control of voltage and milliamperage than had any generator previously used. Some manufacturers later replaced the crossarm rectifier with single or double disks of mica or other insulating materials.

During the next few years, one or more milliammeters were placed into the secondary circuit to indicate the current; primary voltage was regulated with a rheostat control; a prereading voltmeter was placed in the primary line; point and sphere gap voltmeters were placed in the secondary; and separate control stands with protective screens of lead and later of lead-glass were installed. In 1915 the autotransformer control of the primary voltage was added.

In 1917 Coolidge introduced his radiator tube which could act as its own rectifier, provided the load did not exceed the limit and heat the target of the tube. This was produced commercially a few years later and made possible the construction of a portable roentgen-ray unit with a capacity of 85 kilovolts and 10 milliamperes. Waite and Bartlett in 1919 adopted an idea of Thomas Edison's and developed a workable oil-immersed, shockproof unit with a Coolidge tube, which they marketed. This development led to the construction of a small, flexible and safe unit for dental roentgenography.

Around 1920, radiologists asked for roentgen-ray generators that would be capable of producing more penetrating rays, in order to treat deep-seated tumors more successfully. Subsequently a number of American manufacturers (Wappler, Kelley-Koett, General Electric Company, Victor, Standard) built therapy machines with an output of 200 kilovolts and up to 8 milliamperes. These early deep-therapy machines had mechanical rectifiers either of the disk or the crossarm type. After 1926, these slowly were replaced by valve-tube rectifiers. By 1929 most of the diag-

nostic and therapeutic roentgen-ray machines on the market were completely shockproof with transformer and valve tubes immersed in oil, and high-tension wires and roentgen-ray tubes in shockproof cables and housing. Today this type of roentgen-ray machine remains the prototype; the 200-kilovolt deep-therapy apparatus still can be found in most radiological departments.

However, the desire for still more penetrating radiations, both for therapeutic and industrial purposes, brought about various new constructions. One of the early "supervoltage" generators was a cascaded induction coil built by Coolidge with which patients were treated at Memorial Hospital in New York, in 1931. Voltages up to 700 kilovolts with milliamperages in the neighborhood of 3 could be produced with this coil. However, the performance of the apparatus was not too satisfactory and it was eventually replaced by units in which 200-kilovolt transformers were cascaded in four or five steps to produce "supervoltages" as great as 1,000 kilovolts. In 1933 the General Electric Company installed one of the early generators of this type in the Mercy Hospital-Loyola University Clinics in Chicago. It permitted the production of voltages up to 800 kilovolts. Shortly thereafter, the Kelley-Koett Company installed 800-kilovolt "supervoltage therapy" machines in the Charles T. Miller Hospital in St. Paul and in the Harper Hospital in Detroit. Because air under atmospheric pressure was used as insulation for these early supervoltage generators, the equipment was cumbersome and required large rooms and long roentgen-ray tubes to prevent spark-overs.

Work during the following years progressed along various lines of approach toward housing the supervoltage generator in a smaller tank. Sloan in 1932 constructed a high-frequency resonance transformer which was mounted in a still relatively large steel tank. Voltages up to 800 kilovolts could be produced with this generator. It was in clinical use in only two institutions in the United States and was replaced by simpler and more flexible units. One of the latter units is the General Electric low-frequency resonance transformer which was developed in 1939 by Charlton. It is mounted in a tank (diameter of 36 inches and height of 54 inches) and produces 1,000 volts at 3 milliamperes. Later the General Electric Company added a 2,000-kilovolt edition mounted in a correspondingly larger tank. Proper insulation is achieved by filling the tank with freon gas at several atmospheres' pressure. These two supervoltage units today are found in a number of clinical radiation institutions.

A similarly successful supervoltage generator is the constant-potential electrostatic generator that was developed in a practical form by Van de Graaff in 1933. While the first supervoltage electrostatic generators were air-insulated and had to be housed inside an airship hangar or a similarly large structure at the Huntington Memorial Hospital in Boston, small tank units were developed by Trump in 1939. A 2,000-kilovolt generator of this type, for example, is housed in a steel tank 36 inches in diameter and 66 inches high. It can be mounted on a stand or suspended from the ceiling, and thus offers the advantage of flexibility for therapy. The tank is filled with compressed nitrogen and carbon dioxide for insulation. A number of 1,000- and 2,000-kilovolt treatment "Van de Graaffs" have been installed by the High Voltage Engineering Corporation in many radiological institutions.

Roentgen-ray therapy generators producing still higher energies belong to the betatron group. The betatron or "electron accelerator" was devised by Kerst in 1940. In the betatron the electrons are accelerated by a time-varying magnetic field instead of by the direct application of high potential. When sufficient acceleration is attained, the electrons can be made to strike a platinum target to produce roentgen rays. In 1948 the first commercial "clinical 22-million volt betatrons" were

installed by the Allis-Chalmers Manufacturing Company at the University of Saskatchewan and at the College of Medicine of the University of Illinois. Since then, several clinical 24-million volt betatrons have been installed. The Swiss company, Brown Boveri, has installed several 31-million volt betatrons in European medical institutions; the first was installed in Zurich Cantonal Hospital, Zurich, Switzerland, in April 1951.

The development of the high-voltage generator during the last fifty years is nothing short of fantastic: the fickle induction coil and static machines have been replaced by present-day, stable, high-voltage generators and accelerators with well-controllable and reproducible voltages and currents of practically any desired rate.

Roentgen-Ray Tubes. The gas roentgen-ray tubes used in 1906 were as temperamental as the high-voltage generators of that time. In a gas tube the electrons were freed from the cold cathode by a bombardment with positive ions. To obtain positive ions, the residual air or gas in the tube had to be maintained at a low-vacuum. The maintenance of a constant pressure was not easily accomplished since the vacuum and with it the output would change almost with each individual use of the tube. Various regulators were devised to return the pressure to the desired level after it had changed. All of the devices worked, but their effectiveness was of short duration and eventually the tube had to be re-evacuated or "rebuilt."

The diameter of roentgen-ray tubes used at that time ranged between 4 and 8 inches. The tubes were manufactured by Henry Green, John Bauer, Robert Friedlander, Robert H. Machlett, and Greiner, and were sold by Eimer & Amend and MacAlaster and Wiggin. Tubes imported from Germany were made by Emil Gundelach, F. O. R. Goetz and F. Ernecke.

In these roentgen-ray tubes, the cathode was a massive, concave, aluminum disk and the anode was a platinum disk about 1/10 mm. thick. The platinum disk initially was paper thin but it later was welded to a disk of nickel which in turn was soldered to a larger holder of copper, a good conductor of heat.

Numerous minor improvements in the construction of the gas tubes were made between 1906 and 1913. In particular, advances were made in keeping the target or anode cool even for high energies.

In 1913 an important forward step was made with Coolidge's announcement of the construction of a high-vacuum hot cathode tube with a tungsten target. The cathode consisted of a spiral-shaped tungsten wire that could be heated to incandescence when the tube was almost completely evacuated. With this tube, voltage and current through the tube could be separately controlled because the quantity of electrons emitted by the cathode and with it the current through the tube depends upon the temperature to which the filament is heated, whereas the speed of the electrons and with it the quality of the roentgen-ray beam depends upon the voltage at the tube.

The introduction of the Coolidge tube revolutionized both diagnostic and therapeutic radiology. Early Coolidge tubes were made of glass and had to be suspended in special insulating stands, similar to those for gas tubes. The filament was heated by insulated batteries and later by special filament transformers. Early tubes could sustain voltages as high as 100 kilovolts. In the preceding section on high-voltage generators, it was mentioned that Waite in 1919 incorporated the Coolidge radiator tube in his first oil-immersed shockproof unit which became very popular, notably for dental work.

Larger hot cathode tubes with tungsten targets later were developed for voltages of 140 kilovolts and then for as high as 200 kilovolts. For many years these tubes were known as the *Universal and Deep Therapy Tubes.* Unfortunately, with these higher voltages the exposed tubes with their high-voltage overheads and leads became electrical and radiation hazards. These factors

were temporarily overcome by suitable tube-holders and proper mounting of high-tension wires. With the development, in the late twenties, of valve tubes and better insulating materials such as shockproof high-voltage cables, the complete generator tube and cables were mounted in shockproof housing and covers.

By 1930 there were demands for rays produced with still higher voltages. The technical development of Pyrex and other insulators such as porcelain and glass-metal seals permitted the construction of roentgen tubes which could withstand these supervoltages. In addition, Coolidge had constructed cascaded tubes for production of high voltages: that is, tubes that consisted of a number of cylindrical sections or subdivisions that could be connected to various steps of increasing voltages of the cascaded transformers. In such tubes the electrons emitted from the cathode were accelerated as they passed through each section of the tube so that they struck the target with the sum total of the individual boosts, while the strain on the glass of the tube between two individual sections was only a fraction of the total potential accelerating the electrons. The original supervoltage tube with induction coil in the Memorial Hospital in New York was a cascaded tube, but the first commercial tube of that type, as stated previously, was installed in the Mercy Hospital-Loyola University Clinics in Chicago. The Chicago tube had four sections and four cascaded 200-kilovolt transformers, and could accelerate the cathode particles to a speed equivalent to that produced by 800 kilovolts directly.

Another type of the supervoltage machine which was installed a year later in the Charles T. Miller Hospital in St. Paul and Harper Hospital in Detroit did not use a cascaded tube of glass but rather one or two gigantic insulators of porcelain in the center of which the cathode and the target were properly mounted. The heavy porcelain wall was a sufficiently good insulator so that for a size which was not prohibitive it could be used at voltages up to 600 kilovolts. For the production of highly penetrating roentgen rays, two of these tubes could be combined into one, one side carrying +600 kilovolts and the other −600 kilovolts to a total of 1,200 kilovolts. These machines were again air-insulated and required large rooms. The generator and tube, for example, in the Charles T. Miller Hospital was set up in a three-story hall.

Efforts again were made to decrease the size of these supervoltage machines and tubes. As stated previously, the cascaded tubes were considerably decreased in size and were mounted together with the transformers in relatively small steel tanks filled with freon or other insulating gases under high pressure. In some of these tubes the glass has been replaced by porcelain and the doughnut-shaped tube in the betatron also is made of porcelain.

Thus, while the radiologist in 1906 had to struggle along with a highly temperamental roentgen tube as far as output and reproducibility were concerned, his colleague of today has at his disposal a precision instrument whose output in quality and quantity he can fully control. Whether the relatively complicated setup of roentgen-ray generator and tube and its dependence upon electrical line current eventually will be challenged by a different type of radiation generator, such as a radioactive isotope, only the future can tell. For therapeutic purposes it would seem that a cobalt-60 teletherapy apparatus already is in competition with 2- or 3-million volt roentgen-ray therapy machines. For diagnostic work, the radiologist at present has practically any type of roentgen-ray tube he wishes, including those that will stand currents of 1,000 milliamperes at suitable voltages. The performance of isotope diagnostic machines developed so far, for example those using thulium-170, do not yet seriously challenge the performance of the diagnostic roentgen-ray tubes.

Measurements of Roentgen Rays. In 1906 the methods of measurement of quality and

quantity of roentgen-ray beams were unsatisfactory. Some radiologists used parallel spark gaps to ascertain the actual voltage at the tube in order to get some idea about the quality of the beam produced. But there was no uniformity in the type of points utilized in these gaps, some were "needle," others "fine," and others "blunt"; thus, it was almost impossible to evaluate the data obtained, to interpret them correctly later, or to compare them with other findings. Only after the parallel sphere gap came into more general use in radiology with the advent of the deep-therapy machines in the early 1920's, did this method of voltage determination yield more reliable results.

Measurements of radiation quality directly in the roentgen-ray beam also were made in 1906, notably by means of a "penetrometer" or "radiochromomometer" which Benoist had introduced in 1901. This instrument consisted of a thin silver disk surrounded by a ring of aluminum wedges arranged like a stair with 12 steps of increasing thickness. The aluminum step that matched the silver disk in absorption was photographically or fluoroscopically determined, and it represented the radiation quality in "B" units.

A few radiologists also measured radiation quantity at that time. G. Holzknecht in 1902 described his "chromoradiometer" which consisted of small disks of a fused mixture of potassium chloride and sodium carbonate. These compounds became discolored when irradiated with roentgen rays. Holzknecht called the dose producing a minimal degree of discoloration "1*H*." Doses high enough to produce a skin erythema would be of the order of "3*H*." In 1904 Sabouraud and Noiré proposed their "radiometer" which was well received and which was used for several decades, notably by dermatologists. This method was based upon the degree of coloration of small pastilles of compressed barium platino-cyanide varying from bright green ("tint *A*") to deep orange ("tint *B*"). "Tint *B*" represented a full erythema dose.

Efforts to measure the amount of roentgen-ray energy in calories also were made in and before the year 1906 by Dorn, Rutherford and McClung, Wien, and Bumsted. However, the results of these energy measurements were not satisfactory because the actual amount of roentgen energy was minute and the available equipment erratic.

During the subsequent fifty years, roentgen measurements and dosimetry made great strides. C. T. R. Wilson in 1912 demonstrated fog tracks produced by various types of rays in a cloud chamber, and at about the same time von Laue, Friedrich and Knipping discovered that roentgen rays can be diffracted by crystals and therewith proved that roentgen rays belong in the group of electromagnetic wave radiations. This discovery opened an entirely new chapter of studies of the character of roentgen rays by spectrometric methods.

In 1913 Christen suggested the expression of roentgen-ray qualities in half-value layers, a unit that today is internationally acknowledged and used in clinical radiological institutions. From 1914 to 1925 a number of physicists worked on the theoretical and experimental determination of a roentgen dose unit and built various types of instruments for its realization, notably a primary standard ionization chamber for the determination of the dose unit (one roentgen), and secondary instruments with thimble air wall chambers to measure dosages on the patient in the treatment room itself. H. Geiger and W. Mueller in 1928 constructed an improved Geiger counter tube on the basis of the Geiger-Rutherford point counter built as early as 1906. Both types of measuring instruments today are used in variously modified forms for innumerable purposes.

In 1937, the *roentgen* as a dosage unit for roentgen rays and gamma rays was internationally accepted, and in 1953 the recommendations of the International Commission on Radiological Units added the *rad* as the unit of absorbed dose: one *rad* is 100 ergs per gram.

The discovery of the "Compton effect" by A. H. Compton in 1922 enabled greater accuracy in radiation therapy, notably in therapy with more penetrating rays or "deep therapy." The scattering of rays within the tissue augmented the depth doses as shown by measurements with small thimble chambers, mentioned previously, or with extrapolation chambers in body cavities or in phantoms. Isodoses charts were constructed for all conceivable conditions of radiation and they serve today as guides in mapping a sound course of treatment. This work extends to the present day for such studies must provide information for moving beam radiation, pendulum, spiral, or rotation for supervoltage radiation beams.

This brief glance at some of the developments in the technical field of radiology between the years 1906 and 1956 shows the miraculous progress that has taken place within that period of time. It is only with a feeling of awe that one can speculate on developments in this same field in the next five decades.

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THE EARLY HISTORY OF ROENTGENOLOGY IN PHILADELPHIA*†

THE HISTORY OF THE PHILADELPHIA ROENTGEN RAY SOCIETY (1905–1920)

Part I: 1899–1920

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WE ARE especially complimented by being invited to give this lecture because we are merely home talent. You all know our work, our past official relations, and especially our ethical and friendly relations with the members of our Society, and the medical specialties, and the members of the general medical profession. The previous Pancoast lecturers including our own Doctors Chamberlain and Pendergrass have all been distinguished speakers who have presented to you something new or highly technical, or have made very real scientific contributions. We have nothing startlingly new or of any real scientific value.

We do have the special distinction of having been close friends of Henry K. Pancoast. He was a friend and was helpful to all of us who had the privilege of knowing him. He was thorough, conscientious, scientific and had the great satisfaction and benefit of the association and of the criticism of a great faculty of professors in general and special medicine at the University of Pennsylvania. We also have had the pleasure of enjoying the charm and friendship of Mrs. Pancoast from their early wedding days. We are honored by her presence here tonight together with Mrs. Percy Brown, whose husband was one of our first corresponding members.*

My special interest in roentgenology began in 1899. After finishing my residency (fifteen months at the Philadelphia General Hospital), I was appointed Assistant Chief Resident Physician (held for three years). My chief duties were to examine all patients on admission and to assign them to the proper department and to cooperate with the Staff of Resident Physicians now called "Internes." I look upon these four years and three months service in the Philadelphia General Hospital as the best years of my professional life. This general experience together with extensive autopsy observations, I believe, has been the most valuable preparation for the practice of roentgenology.

One morning in 1899 the Chief Resident Physician, Dr. Daniel E. Hughes, at our usual morning Conference said, "Dr. Pfahler, the Board of Directors have decided to install an x-ray machine and they want you to operate it." I answered, "Dr. Hughes, I can see no future in this field. All of the bones of the body and foreign bodies have been demonstrated." (Joke on me and a demonstration of my ignorance.) "But," I continued, "I am here to do what I am told." He fortunately did not agree with my opinion of the insignificance of roentgenology. My chief interest was in the preparation for the general practice of medicine.

Now, after fifty-five years of work and study in radiology, I realize how little I know and how much more I should know of the special techniques and diagnostic abilities with which many of you younger

* In 1936, Dr. Brown who was one of our greatest and longest suffering martyrs had prepared an excellent book on "American Martyrs to Science Through the Roentgen Rays." Percy Brown, M.D. (He died October 8, 1950.) Charles C Thomas, Publisher, Springfield, Illinois.

* Presented before the Philadelphia Roentgen Ray Society as the 14th Annual Henry K. Pancoast Lecture, November 4, 1954.

† Notes or records are based upon the minutes of the Philadelphia Roentgen Ray Society and the personal memories and experiences of the authors. Dr. Pfahler has been assigned to the History from 1899–1920; Dr. Bromer has been assigned to the period from 1920–1954 inclusive. For the sake of brevity, it is self-evident that only generalities can be recorded. The late President Bart M. Allen requested this review and record during his administration in 1950, but his death interrupted the preparation of this history.

Fig. 1. Leonard at work in his early roentgen ray days at the Hospital of the University of Pennsylvania. Notice the equipment and arrangement. Dr. Leonard is standing beside the control switch and the small induction coil supported by a small table with the roentgen tube on a small portable stand over the patient's chest, with the patient on a ward carriage. Note also the pyramidal shaped fluoroscope, to be held in the hand, and the penetration of the rays tested with the other hand in front of the fluoroscope exposed to the naked or unprotected roentgen tube.

men in this audience are acquainted in this great medical specialty.

The meager space and equipment which were available in 1899 is illustrated by my own experience at the Philadelphia General Hospital, but the importance of the subject can best be gauged by the fact that a special ground floor room was built of concrete 12 by 15 feet—180 square feet of floor space; 3 feet were separated for a photographic developing room, leaving a total space of 12 by 12 feet for the equipment and furnishings, consisting of a Ruhmkorff coil and a small adjustable tubestand and roentgen-ray tube. A ward carriage was used as a table. I did not make a photograph of the roentgen-ray room, but I can demonstrate to you a picture of the room, equipment, ward carriage, and a picture of our distinguished pioneer, Dr. Charles Lester Leonard (whose painted portrait is hanging in this room) taken at the University of Pennsylvania Hospital, where Dr. Leonard was in charge at that time (Fig. 1 and 2). Dr. Leonard guided us at the Philadelphia General Hospital in the matter of installation and technique, for which I shall always be grateful. Dr. Pancoast began work with Dr. Leonard in 1902, at which time their room was about 10 by 20 feet, and in 1903, Dr. Pancoast took over and remained as Director until his death on May 20, 1939. Today, the radiologic department consists of 25,000 square feet at the University Hospital, under the direction of our distinguished fellow member and Dr. Pancoast's successor, Dr. Eugene P. Pendergrass and his associates and assistants. At the Philadelphia General Hospital, with the expansion now being developed, there will be 22,500 square feet, under the direction of another distinguished fellow member, Dr. Bernard P. Widmann and his associates and assistants.

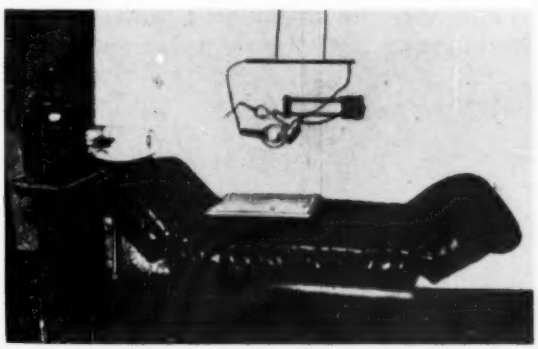

Fig. 2. The famous couch in Dr. Leonard's office on South 20th Street, whereon were conducted most of the long series of examinations which made up his pioneer work on urinary calculus. Note the small coil on a table, an ironing board supporting a glass plate on the couch. Note also the tube hung from cords and demonstrating very well the auxiliary tube used for regulation of the vacuum.

At the beginning of my work at the Philadelphia General Hospital, we were fortunate in having obtained the largest Ruhmkorff coil then available, which pro-

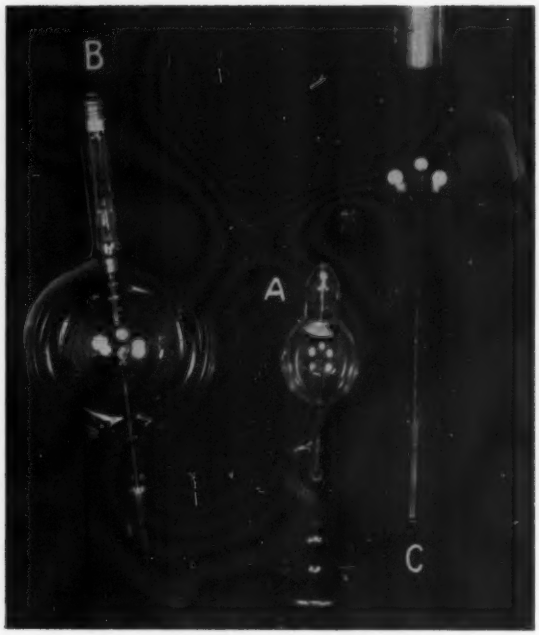

Fig. 3. (*A*) One of the first roentgen tubes made in Philadelphia, showing a cup-shaped cathode and a very thin platinum anode. (*B*) The universal Coolidge tube, 1913. (*C*) The early high voltage Coolidge therapy tube.

duced a 15 inch spark. We had no milliammeter and not even an ammeter and no voltmeters. The voltage was judged by the parallel spark gap which registered the resistance of the vacuum in the roentgen tube and gave us an estimate of the penetrative value of the rays. The intensity of the radiation had to be judged by the experience with the photographic *plates* and by the reaction which developed on the skin of patients that were under treatment, but *especially by holding a hand before a fluoroscopic screen.*

The roentgen rays produced depended not only upon the high tension current and the volume of the current but even more upon the behavior of the roentgen tube which was very erratic. The bulb of the first roentgen tube which I am demonstrating to you was approximately 3 inches in length and $2\frac{1}{2}$ inches in diameter (Fig. 3), but even this miniature which was used by my classmate, the late Dr. Mihran K. Kassabian, at the Medico-Chirurgical College Hospital, was a very great improvement over the tube originally used by Professor Röntgen. This tube had a cup-shaped cathode and a paper-thin aluminum anode or target. In 1899, the Queen Company of Philadelphia developed the Sayne tube with which there was an automatic regulator which kept the vacuum of the tube fairly constant. This type of tube was used by both Dr. Leonard and myself in 1899, and also by most of the other pioneers in roentgenology (Fig. 2). With this tube when the vacuum increased under use, there would develop a shunt current over an adjustable spark gap which released a slight amount of gas from the asbestos packing in the auxiliary tube, and reduced the vacuum to a satisfactory degree, as I will demonstrate to you in a lantern slide. All of you are acquainted with the tremendous advancement in tubes and equip-

Fig. 4. Shows the roentgen equipment set up for photography in one of the rooms with marble walls and marble floor, in the operating amphitheatre building of the Medico-Chirurgical College and Hospital. Notice Dr. M. K. Kassabian in the position of making a fluoroscopic examination of the chest of one of the internes. The roentgen tube is excited from a small induction coil in a glass-walled case. Note also the static machine which could also be used for the production of the roentgen rays. Note also the sample "x-ray photographs" made by Dr. Kassabian including a whole skeleton, and the full length body print, made in 1901.

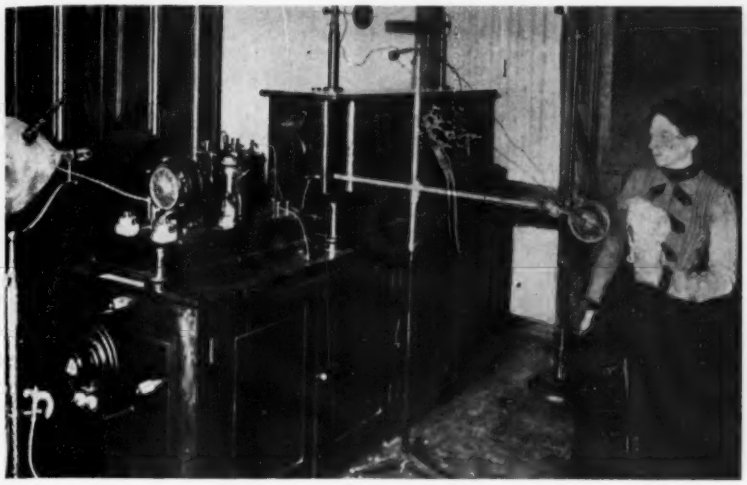

Fig. 5. Illustration 180, in Dr. Monell's "Studies in X-ray Therapy," photographed by Blackmarr, showing the position of the patient, the tube, and the induction coil during the treatment of carcinoma of the breast. Note especially the patient holding the lead shield and the small hole in the lead shield permitting the rays to reach the breast; no protection around the tube and no protection to the remainder of the patient's body.

ment during these past fifty-five years. We owe much to the special engineers and manufacturers who have produced this marvelous equipment which we use today.

Even with this meager equipment (Fig. 1, 2, 4 and 5) really remarkable results were obtained which represented definite advances in both diagnosis and treatment in medicine. Dr. Leonard succeeded in demonstrating a stone in the kidney in 1898, to be followed by other similar demonstrations elsewhere in the world. At the Philadelphia General Hospital, there was an unlimited amount of pathological material permitting much experience and assistance in the diagnosis of what were formerly obscure conditions. We had the very great advantage of autopsy study and confirmation of diagnoses because during that period, Dr. John V. Shoemaker, who was Director of Health, issued an order for the City of Philadelphia that there should be an autopsy on all patients dying in the Philadelphia General Hospital. This gave great opportunities for us to study the body during life and sometimes on the corpse on the way to the morgue, and then permitted observations at autopsy.

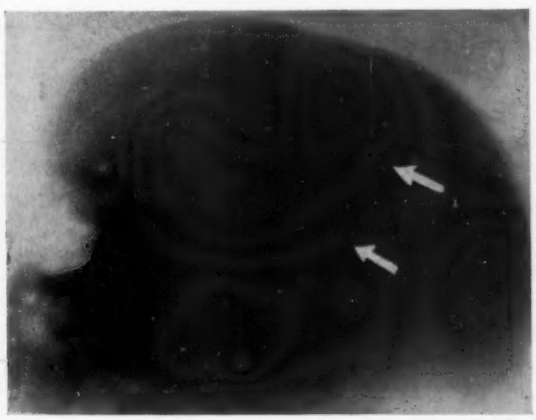

Fig. 6. Reproduced from a lantern slide of a brain tumor, operated upon December 11, 1901, showing a dumbbell-shaped tumor. The roentgen examination was made 11/23/1901.

One of the distinct advances in medicine was referred to by the President of the German Neurological Society at the Annual Meeting of 1902, which I believe was the first brain tumor clearly demonstrated anywhere in the world. The clinical diagnosis and location of the tumor had been made by Dr. Charles K. Mills. This was confirmed or rather demonstrated by my roentgenologic examination, and at operation by the late Dr. J. C. DaCosta, and with Doctors Joseph C. Hearn, Charles K. Mills, Charles Burr, and Theodore Weisenberg, who were present at the operation. The brain tumor was removed December 11, 1901, and I received great congratulations, but I had found a dumbbell-shaped tumor (Fig. 6), and I said, "If I have demonstrated the tumor, then only half of the tumor has been removed." Two days later, at autopsy, the other half was removed. This was reported by Dr. Charles K. Mills and myself in literature. Other diagnostic

FIG. 7. Shows carcinoma of the right inner canthus, treated at the Philadelphia General Hospital in 1900, and reported at the First Scientific Meeting of the American Roentgen Ray Society, in 1901, published in "Therapeutic Gazette," in 1902, and republished in "Annales d'Electrobiologie," in Paris, France.

advances were also made. I will show you the lantern slide.

FIG. 8. Shows a recurrent sarcoma five days after the third operation by Dr. Wm. L. Rodman. *A* shows the recurrence; *B* shows the lesion healed eleven months after the beginning of treatment.

FIG. 9. *C* shows the destruction of the tumor completely on the right side of the face; *D* shows the effect of the penetrating rays on the left side of the face *without any direct irradiation on the left side*, proving even in those early days we were using penetrating rays.

Some definite results were also obtained by roentgen-ray treatment. I made a report[2] on four of these early cases of epithelioma successfully treated, at the First Scientific Meeting of the American Roentgen Ray Society, held in Buffalo, 1901. I demonstrate now to you pictures of these patients (Fig. 7, 8 and 9). This was of sufficient importance to be republished by request in Paris, France.[3]

One of the great accomplishments in the early days of roentgenology in Philadelphia was the organization of the Philadelphia Roentgen Ray Society.

A BRIEF HISTORY OF THE PHILADELPHIA ROENTGEN RAY SOCIETY

From 1905 to 1920*

We may be justly proud of our Society, because from the beginning we have striven to uphold the highest type of ethical conduct and the closest spirit of friendship and cooperation with each other, and with the general profession of medicine. We have followed the principles governing scientific medicine and have struggled to justify and obtain recognition of radiology as a medical specialty. We may also be proud of the many valuable scientific contributions to medical radiology made by our members, and proud of the national and international recognition given to our members.

Under the leadership of our pioneer, Dr.

* For the sake of brevity, the many less important details in the records have been omitted.

Charles Lester Leonard, we were invited to an organization meeting at his private office at 112 South 20th Street, Philadelphia, on February 2, 1905. The founders who were present were Mihran K. Kassabian, M.D., Charles Lester Leonard, M.D., S. Mason McCollom, M.D., William S. Newcomet, M.D., Henry K. Pancoast, M.D., George E. Pfahler, M.D., H. H. Riddle, M.D., John B. Schober, M.D. (gynecologist), Homer C. Snook (engineer), Henry W. Stelwagon, M.D. (dermatologist), Thomas Stewart, M.D., and William M. Street, M.D. (ophthalmologist).

The object of the Roentgen Society of Philadelphia was "The study of the roentgen rays and the formation of friendly intercourse."

There were twelve founding members, and the limit was to be fifteen (this limit was soon changed and now there are 207 members). New members were to be elected by unamimous vote. This latter provision contributed to the very friendly cooperation which always existed in these intimate meetings. The officers of our Society consisted of a permanent secretary, Dr. Leonard, who was also Chairman of the Committee on Arrangements. The other members of this arrangement committee were to be the host-chairman of the concurrent meeting, together with the succeeding host. The late Mr. H. Clyde Snook served as recording secretary. To him we are indebted for the very brief handwritten record of these old meetings. Of this original group of founding members, only Dr. William S. Newcomet and I remain.

The corresponding members elected at the first meeting were Russell H. Boggs, M.D., and George C. Johnston, M.D., of Pittsburgh, Ennion G. Williams, M.D., of Richmond, Va., Eugene Caldwell, M.D., of New York, and Percy Brown, M.D., of Boston, Mass. These corresponding members occasionally honored us with their presence.

It was voted at the organization meeting "No refreshments shall be served." This rule was also soon changed and snacks and soft drinks were served by the hosts after the scientific discussion. This sociability led to more friendly and intimate discourse of personal problems.

The first succeeding meeting after organization was held at the office of Dr. McCollom on Arch Street, and was devoted to *The Protection of the Roentgen Ray Operator*, which shows that in 1905, we had already become conscious of our dangers. At the third meeting which was held in my office (1409 Spruce Street), discussion of protection was continued, and cases of dermatitis which developed a year or more after irradiation had been stopped were presented and discussed informally. At this third meeting, Dr. Kassabian demonstrated a plate which showed the femoral artery. This indicated in these early years blood vessel studies were being made. (In 1901, Dr. Joseph Sailer and I at the Philadelphia General Hospital recognized fluoroscopically and roentgenographically, and studied at autopsy, and published our observations on *Tortuosity of the Aorta Resembling Aneurysm.*[4])

It was the custom at these meetings to bring plates of interesting or unusual or difficult cases to be discussed informally, with all the members standing around the illumination box. This was an early example of film reading sessions, so well developed later by Drs. Pancoast and Pendergrass at the University Hospital, and later by Dr. Pendergrass at our Society meetings, which discussions are now being carried on under the able leadership of Dr. Lehman.

In the fall of 1906, it was decided to arrange for a symposium on *The Diagnosis of Tuberculosis*, held at the meeting of the Philadelphia County Medical Society on January 7, 1907, at which Drs. Henry Hulst, of Grand Rapids, Michigan, Eugene Caldwell, of New York, and Russell H. Boggs of Pittsburgh, were guest speakers, and represented roentgenology. (A reception was held after the meeting with refreshments, at a cost to our members of one dollar.) It was also decided to recommend that the American Roentgen Ray Society arrange for a plate and lantern slide exhibit for the American Roentgen

Ray Society Meeting at Atlantic City, in June 1907. This indicated our leadership in developing dignified public relations with the general medical profession.

In 1913, our great pioneer, leader, and permanent secretary, Dr. Charles Lester Leonard, died from the damaging effects of his early roentgen ray exposure. At my proposal, it was then decided to organize formally as "The Philadelphia Roentgen Ray Society." On December 1, 1913, a new Constitution and By-Laws were adopted and regular officers were elected: President, George E. Pfahler, M.D.; Vice-President, Henry K. Pancoast, M.D., and Secretary-Treasurer, David R. Bowen, M.D.

At this time, it was also decided to organize a *Post-Graduate Course for Instruction in Roentgenology. So far as we know, this was the first formal course of instruction for a class in roentgenology organized by a faculty of roentgenologists in the United States.* This faculty included the roentgenologists in charge of the radiologic departments in the leading hospitals. In its nature, it was the forerunner of the Graduate Medical School of the University of Pennsylvania.

A letter asking for approval was written to and consent was obtained for this clinical instruction, to be given by the leading radiologists in our Society at the following hospitals: University of Pennsylvania, Medico-Chirurgical, Jefferson Medical, Presbyterian, Oncologic, Pennsylvania, and the Philadelphia General Hospital. This course was given to six graduate physicians. The instruction consisted of demonstrations of patients, technique, and discussions of the practical clinical problems. The class was limited to not more than six and not less than five. The course involved one month of instruction. The class was kept busy all day and the fee was $150.00 payable in advance. The course seemed to be a complete success.

On February 27, 1914, a joint meeting of the Philadelphia and New York Roentgen Ray Societies was held at the Waldorf Astoria Hotel, when Dr. Samuel Stern gave a very instructive discussion in deep roentgen therapy as used in gynecological cases at the Freiburg Clinic in Germany. This was followed by an exhibition of a large number of interesting lantern slides by members of the two societies. At the end of this meeting, a collation and social session was enjoyed by all.

On March 13, 1914, the regular scientific program was suspended because we had as a guest, Dr. Lillienfeld of Leipzig, Germany, who addressed us on (1) *The Theory That Only Energy Absorbed Decides the Therapeutic Effect of the Roentgen Rays*, (2) *A Description of the Roentgen Tube Recently Devised by Dr. Lillienfeld*, and (3) he made the interesting announcement that while working with this tube and using rays of from 15 to 20 Wehnelt (quality) he had been able to regenerate barium platinocyanide, which had previously been browned by exposure to softer rays. The fluorescence of the chemical had also been recovered. (At that time barium platinocyanide disks were used to determine the erythema dose by direct measurement.)

On April 11, 1914, the regular meeting was omitted and an open meeting for members and guests was held on a Saturday night in the clinical amphitheater of the Medico-Chirurgical Hospital, which was to be addressed by Dr. Alfred C. Jordan of London, England. The subject was the *Study of the Physiological and Pathological Functions of the Gastrointestinal Tract.* Dr. Jordan's steamer was late on arrival and he could not be present. Those who were present were treated to a very interesting address by Dr. Hertzoghe of Holland, on the subject of *Hypothyroidism.* He described typical cases and called particular attention to the frequency of what he termed "mild thyroid weakness."

Another special meeting for members and guests was held on Thursday evening April 16, 1914, in the Medico-Chirurgical Amphitheater, to hear Dr. Jordan deliver a most instructive address on *Intestinal Stasis.*

On November 7, 1914, the New York Roentgen Ray Society was invited for a joint meeting with us at the Hotel Adel-

phia, Philadelphia. There were present 35 members and guests. The members were:

Drs. Borzell, Bowen, Daland, Edwards, Feldstein, Manges, Meter, Miller, Newcomet, Pancoast, Pfahler, Stewart, and Westcott, and Mr. Snook. The guests from New York were: Drs. Caldwell, Imboden, Jaches, Stewart, LeWald, Mackee, and Law; from Washington, D. C., Dr. Selby; from Richmond, Va., Dr. Alfred C. Gray; from Ithaca, N. Y., Dr. S. Shearer, Professor of Physics at Cornell University; from Wilmington, Del., Dr. H. A. Cleaver. Guests from Philadelphia were Mr. Edwin Kelly, Drs. Sender, Hutton, Frank, Newburg, Fisher, Percival, Zulick, Dorrance, and Baird.

Mr. Edwin Kelly read a paper on the hydrogen roentgen-ray tube and gave interesting demonstrations with the "ordinary" and the "air-cooled type."

Dr. Shearer (Cornell University) gave a paper on some measurements made with the Coolidge tube.

Interesting lantern slides were shown and discussed by members of both Societies. Arrangements were made to hold a midwinter meeting at Atlantic City. Flowers were ordered sent to our distinguished colleague, Dr. Fred Baetjer, who was in the Johns Hopkins Hospital for another operation due to radiation damage.

On March 12, 1915, the following corresponding members were elected and from time to time honored us with their presence: Dr. Frederick Baetjer of Baltimore; Dr. Preston M. Hickey of Detroit; Drs. William H. Stewart, Leopold Jaches, Lewis G. Cole, of New York; Dr. Alfred C. Gray of Richmond, Va., and Dr. H. A. Cleaver of Wilmington.

At the annual meeting on May 14, 1915, new officers were elected: President, Dr. Henry K. Pancoast; Vice-President, Dr. Willis F. Manges, and Secretary-Treasurer, Dr. David R. Bowen, and regular schedules of meeting places were agreed upon for the succeeding year.

On October 14, 1915, it was decided to arrange a joint meeting with the Philadelphia County Medical Society, to be held in February, 1916, on the subject of the clinical and roentgenological diagnosis of pulmonary tuberculosis. Not more than ten cases were to be presented and each by an internist and a roentgenologist. Instead of this arrangement at this joint meeting with the County Medical Society, Dr. Kennon Dunham of Cincinnati, discussed: *The Specific Roentgen Findings in Pulmonary Tuberculosis*, and Dr. H. R. M. Landis of Philadelphia, discussed: *The Clinical Diagnosis of Pulmonary Tuberculosis*. A dinner in honor of the guests was arranged by our Society preceding the scientific meeting.

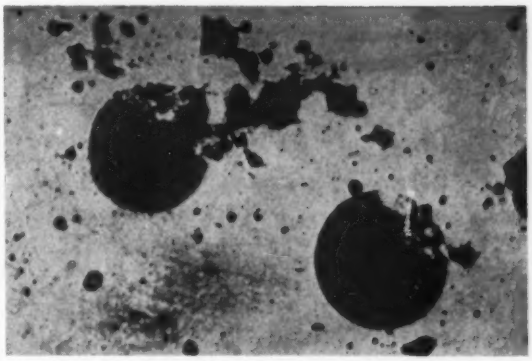

Fig. 10. First "x-ray photograph" made in Philadelphia accidentally by Dr. A. M. Goodspeed, 1890 or about five years before the discovery by Professor Röntgen. Dr. Goodspeed's teaching schedule was so full that he did not follow through and make the discovery of the roentgen rays at this early date.

At the regular meeting held at Dr. Frederick Hutton's office, March 9, 1916, an amendment was added to the Constitution as follows: "Scientists who are especially distinguished for their efforts in roentgenology may be elected to Honorary Membership." Dr. Arthur Goodspeed, Professor of Physics at the University of Pennsylvania, was the first to be so honored—*he had obtained x-ray photographs in 1890* (Fig. 10). This was five years before Professor Röntgen made his discovery, but unfortunately Professor Goodspeed had a busy teaching schedule and did not follow through. He told me that he was not proud of this.

The regular May, 1916, meeting was replaced by a dinner meeting at the Rittenhouse Hotel, where our guest speaker was

Dr. Fred H. Heise, who was the resident physician of the Adriondack Cottage Sanatorium. He gave a most interesting discussion of pulmonary tuberculosis with demonstrations by means of lantern slides and roentgenograms, assisted by Mr. Sampson, his roentgenologist (technician).

At the June 8, 1916, meeting the following officers were re-elected for the ensuing year: President, Dr. Pancoast; Vice-President, Dr. Manges; Secretary-Treasurer, Dr. Bowen. Dr. Newcomet, Chairman of the Committee from our Society, reported that the Olivet Mason's Lodge joined us in honoring Dr. M. K. Kassabian, one of our earliest martyrs, by placing a headstone at his grave in Mt. Moriah Cemetery, 62nd and Kingsessing Ave., Philadelphia.

The December, 1916, meeting was given over to a farewell dinner to Mr. and Mrs. H. Clyde Snook, to which the members and their wives were invited. These great friends of our Society were moving to Chicago.

At the Annual May Meeting held in June, 1917, at Dr. Manges' office, the following officers were elected: President, Dr. Willis F. Manges; Vice-President, Dr. David R. Bowen; Secretary-Treasurer, Dr. Frederick Hutton.

On December 12, 1917, our Society entertained the New York and New England Roentgen Societies at a dinner at the Rittenhouse Hotel, preceding the scientific meeting. There is no record of the program.

On May 9, 1918, the following officers were elected: President, Dr. David R. Bowen; Vice-President, Dr. Milton F. Percival, and Secretary-Treasurer, Dr. Frederick Hutton.

On November 13, 1919, at the regular meeting at Dr. Percival's office, an amendment to the Constitution was adopted. It had been proposed by Drs. Pancoast and Manges on March 13, 1919, and read as follows:

"Section I—Article 3 to be stricken from the Constitution. *Section III to read: Members shall be regularly licensed to practice medicine and shall be of unchallenged professional reputation and shall be actively engaged in the practice of roentgenology.*" This was advisable because of commercial laboratories which were developing where roentgenograms were being made and sent to physicians who made their own interpretation.

On account of the war, only a few meetings were held during 1917, 1918, and 1919. On June 25, 1919, a meeting was held at the Whitemarsh Valley Country Club, at which Dr. William H. Stewart of New York presented his work on *The Intra-abdominal Injection of Oxygen as an Aid in Roentgen Diagnosis.*

At the meeting held at the Frankford Hospital, October 9, 1919, the following officers were elected; President, Dr. William S. Newcomet; Vice-President, Dr. Milton F. Percival; Secretary-Treasurer, Dr. Frederick Hutton. At this meeting, Dr. Newcomet was requested to investigate the possibility of having a milliamperemeter standardized and purchased by the Society. This action was completed and at the December 11, 1919, meeting at the Oncologic Hospital, a standardized Weston milliamperemeter was ordered purchased.

In January, 1920, the Society took on more normal activities again, and it has developed into one of the great Societies of the nation.

Dr. George E. Pfahler
1930 Chestnut St.
Philadelphia 3, Pennsylvania

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THE HISTORY OF RADIOLOGY IN PHILADELPHIA*

THE HISTORY OF THE PHILADELPHIA ROENTGEN RAY SOCIETY

Part II: 1920–1954

By RALPH S. BROMER, A.B., M.D.
BRYN MAWR, PENNSYLVANIA

TO BE asked to give a part of the Pancoast Lecture for 1954 is an honor which I greatly appreciate. If affords me an opportunity to pay tribute to Dr. Pancoast, a teacher of exceptional talent and one of the charter members of the Philadelphia Roentgen Ray Society who through his character, his attainments and his many contributions to Radiology, did so much to influence its development and growth as a specialty. It was my good fortune to start practice in a period of time which permitted me to know him personally and to have his assistance and guidance. As Dr. Pfahler has said the Society has endeavored to promote the highest type of ethical conduct and the closest spirit of cooperation and friendship. I am sure that all of us who knew Dr. Pancoast appreciate how much he did to attain these aims.

I accepted the honor of giving the history of radiology in Philadelphia since the First World War with some misgiving. The history of radiology in Philadelphia is for the most part the history of the activities and records of the Philadelphia Roentgen Ray Society. The part assigned to me covers a period of thirty-five years, from the conclusion of the War to the present time. Webster's definition of history is in part, "a full account of the past with interpretative and explanatory comment that distinguishes it from mere annals or chronicles." Mere annals would consist in my giving an account of meetings, motions and members rising to points of order, or "I move the motion be tabled," which would be too long and in fact too boring. Instead of "interpretative and explanatory comment" I have chosen to include mention of policies pursued by the Society, the list of foreign radiologists who addressed the Society, notable occasions such as anniversaries of the founding of the Society, anecdotes, reminiscences and humorous incidents, the list of officers from this Society in national and international organizations, and other interesting items.

In preparation of this paper, I spent much time in study of the minutes and from them I have collected the most interesting occurrences. During the First World War, Dr. Fred Hutton was the secretary and treasurer of the Society and I followed him in 1921. The minutes were written in long hand until Dr. Eugene P. Pendergrass succeeded me in 1924. In 1919 the secretary and treasurer's offices were combined as they had been previous to the War. The Society had little money in the treasury at that time but back dues were promptly paid and sufficient reserve was on hand for running the Society in an efficient manner. Meetings were at first held in offices of the members or in the radiologic departments of the members holding hospital appointments. In 1923 the invitation of the Pennsylvania Hospital to hold the meetings in the Assembly Room of the Hospital was accepted. This continued until 1930 when the meetings were transferred to Thompson Hall of the College of Physicians. By that time the attendance of members and guests had required a larger meeting place.

The Twentieth Anniversary Dinner was held on February 19, 1925, at the Sylvania Hotel. Five of the charter members of the Society were present: Drs. Newcomet, Pfahler, Pancoast and Stewart and Mr. H. Clyde Snook. Dr. Widmann presided as President of the Society. Dr. Thomas A. Groover of Washington, D.C. read a paper

* Presented as part of the Pancoast Memorial Lecture of the Philadelphia Roentgen Ray Society, November 4, 1954.

on *The Cancer Problem. The Consideration of Some of the Newer Ideas of Treatment by Surgery and Irradiation.* Mr. H. Clyde Snook presented: *Some Developments by the Bell Telephone Company's Research Laboratories in the Art of Electrical Communication.* Dr. Percy Brown reviewed the earlier years in the practice of roentgenology. Dr. Pfahler spoke on *The Early Days of the Society* and thanked the Society for the loyalty among its members. Drs. Newcomet, Pancoast, Manges and Stewart made a few retrospective remarks following which the meeting adjourned.

The minutes for the meeting of March 5, 1925 noted that an unusually large audience was present, 55 members and guests. The Society was growing rapidly. The subject discussed at the meeting that evening was *Dangers of X-ray Work and How to Avoid Them.*

At the meeting of February 7, 1929, a revised Constitution was adopted and the charter of the incorporation was accepted. The organization thus became the Philadelphia Roentgen Ray Society, Inc.

In the minutes of the meeting of January 3, 1929 is the following: "Dr. L. A. Milkman of Scranton by invitation presented the films of an interesting and unusual case of bone disease. The condition was unlike anything that any member of the Society had ever before seen. It was characterized by symmetrical multiple fractures of the long bones with relatively little displacement of the fragments. The condition had been progressive." Dr. Milkman later became a member of the Society. The members thus had the opportunity of seeing his famous case before it was reported and published in the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY. By reporting this case he made a noteworthy contribution to the knowledge of osteomalacic disease of bone.

At the November, 1930 meeting Dr. Pfahler gave an interesting talk on "*Some Radiological Impressions from Germany, Austria and Hungary.* He spoke of the rotating target for prevention of overheating of the roentgen tube; an exposure meter which registers the amount of exposure on the films; a rotating table for examining patients in various positions; the Hohlfelder cannon for roentgen treatment; compression rubber bags for examination of the stomach and duodenum; intravenous pyelography; study of the rate of growth; the treatment of malignancy by means of oxygen and carbon dioxide. This is illustrative of subjects which were interesting and comparatively new at that time.

The minutes of the meeting, October, 1930 state that "Dr. William E. Chamberlain, Professor of Roentgenology, Temple University, recently of Leland Stanford University, San Francisco, was presented to the Society and spoke a few words regarding his impression of the Philadelphia Roentgen Ray Society." Unfortunately there is no record of his remarks. I was reminded the other evening that he was introduced by the President, Dr. John T. Farrell, Jr., as the "Young Lochinvar Come Out of the West."

At that same meeting a Bone Tumor Registry to be under the control of the Society was brought up and after some debate was approved. This intention of forming a Bone Tumor Registry had a rather hectic career of non-existence. (I speak frankly as I was one of the members of the committee to institute it.) At the meeting of April, 1932, a report was made that only 5 cases had been registered. An appeal was made for more cooperation. There were not sufficient cases registered to arrange an exhibit for the Mid-Winter Inter-Society Conference. The Bone Tumor Registry then lapsed into a state of innocuous desuetude. This in part was due to lack of cases registered, insufficient histories and microscopic slides and especially because of lack of space for storing and exhibiting the cases. Finally in 1945, a new committee was appointed to cooperate with the Orthopedic Club of Philadelphia, the Academy of Surgery, and the Pathological Society of Philadelphia concerning the planning and formation of a Bone Tumor Registry. At the meeting of December 6, the same year, the Society voted to contribute three hundred dollars for the first year toward the expenses of establishing a Bone Tumor

Registry, provided the other societies would do likewise and provided that the American Cancer Society contribute $2,400.00. On March 17, 1946, Dr. Pfahler reported that the Philadelphia Division for the Control of Cancer was considering the formation of a Central Registry for all types of cancer. Dr. Colonna, the Chairman of the Joint Committee of the Societies, therefore had dissolved the Joint Committee. At a previous meeting of our Society, 68 members had expressed their willingness to cooperate in the reporting of cases.

MANGES MEMORIAL MEETING

On April 1, 1937 the Willis Fastnacht Manges Memorial meeting was held. The resolution adopted by the Society at the time of his death was first read. This was followed by the reading of a poem by Dr. Leon Solis-Cohen; *The Roentgen Treatment of Infections* by Dr. Richard Manges Smith, one of Dr. Manges' pupils, a subject in which Dr. Manges had been greatly interested; *Contribution of Dr. Willis F. Manges to Bronchoscopy* by Dr. Chevalier Jackson, the speaker giving details of his pioneer work in detection of nonopaque foreign bodies in the lungs; Dr. Farrell spoke of Dr. Manges as a chief; and Dr. William S. Newcomet gave a talk on *Early Reminiscences of the Philadelphia Roentgen Ray Society*. Dr. Pfahler then presented the Manges Portrait which hangs upon the south wall of this meeting room. Telegrams were read from Dr. B. R. Kirklin of Rochester, Minn., Dr. Leopold Jaches of New York, Dr. Lawrence Reynolds and Dr. William A. Evans of Detroit, expressing their deepest regret that they were unable to attend. The Society voted to present the portrait of Dr. Manges, which had been painted for the Society, to the College of Physicians with the request that it be hung on the wall of Thompson Hall, the meeting room of the Society.

Dr. Manges made many contributions to roentgenology and some of them were listed in the minutes as follows: "(1) his announcement of the first mathematically accurate method of pelvimetry, (2) his introduction of fluoroscopic control of pyelography, (3) his development of an efficient organization of the training school for Army officers in roentgenology at Camp Greenleaf during the First World War, (4) his vivid description of the mechanism and diagnostic significance of obstructive emphysema and atelectasis in connection with foreign bodies and various endobronchial lesions, (5) his work with Chevalier Jackson in the application of biplane fluoroscopy to the problems of recovery of foreign bodies from the air and food passages, (6) his successful application of the biplane fluoroscope to the problem of localizing and removing foreign bodies from the eye."

On May 6, the next regular meeting of the Society was addressed by Dr. Pfahler who gave a description of the life of Dr. Lester Leonard, whose early part in the formation of the Society was described by Dr. Pfahler this evening. His portrait was unveiled and by vote of the Society was presented to the College of Physicians and now hangs on the east wall of this meeting room.

DR. PFAHLER'S GIFTS

Dr. Pfahler has always shown great interest in the Society which is indebted to him for several gifts. The first is the President's gavel presented in 1930. It is made of mastodon ivory obtained in Alaska. The mastodons were present in the Pleistocene Period, probably more than 25,000 years ago, when Alaska had a tropical climate. Some of these mastodons became mired in the mud and the bones were fossilized, then covered with glaciers as the cold period followed, and were buried in the ice during the Glacial Period. The tusks are now being discovered in the melting glaciers. It was presented in a case, the lid and sides of which are large enough to have the name of each President, year by year, engraved upon it.

At the meeting of March 4, 1940, it was voted to contribute the sum of $1,000 to the Library of the College of Physicians of Philadelphia (in part from the sum remaining from the dinner given in honor of Dr. Pfahler), the gift to be known as "The

Fund of the Friends of George E. Pfahler, the books purchased with the money, to be suitably marked." At the April meeting a letter was read from Dr. Pfahler stating that he greatly appreciated the Society's action and that he was contributing an equal amount to the Fund. Later in 1940 and in 1943 he further augmented the Fund by $2,000. In 1942, Dr. Lawrence Reynolds donated the honorarium he had received as the Pancoast Lecturer for that year and the Fund now amounts to $4,100.

At the meeting of March, 1943, Dr. Pfahler presented a bust of Professor Röntgen to the Society. In his brief presentation he included a short history of the artist who executed the bust and mentioned the favorable criticisms of the bust which had been given him by persons who had known Professor Röntgen. At the October meeting of this year, Dr. Pfahler presented the Society with a new bronze bust of Röntgen which was to be substituted for the original one given by him. It is a bronze cast of the original which had served as a plaster model for the bronze replica.

DINNERS

The Society must have a reputation for dining. At the early meeting refreshments or "snacks" were provided after the meetings. A period followed in which pre-meeting dinners were held at the old Rittenhouse Hotel very close to the meeting place in the College of Physicians. The New York and New England Societies were entertained at a dinner meeting at the Normandie Hotel. A few pre-meeting dinners were held in 1931 at the Penn Athletic Club and later at the Belgravia Hotel. Similar dinners are now being held in the College of Physicians.

On January 25, 1940 a testimonial dinner was given to Dr. Pfahler at the Warwick Hotel. Presidents, Presidents-elect and Secretaries of the National Radiological Societies and the President of the Philadelphia County Medical Society were invited to attend the dinner. The menu has been preserved by many of the members of the Society. The speakers of the evening were: Dr. Eugene P. Pendergrass, Toastmaster; Dr. Joseph E. Roberts, President of the Philadelphia Roentgen Ray Society; Dr. Francis F. Borzell, President-Elect, Pennsylvania State Medical Society; Dr. George H. Meeker, Dean, Graduate School of Medicine, University of Pennsylvnaia; and Dr. Joseph McFarland, Professor of Pathology, University of Pennsylvania.

On June 12, 1942 a testimonial dinner was given to Dr. William S. Newcomet at the Philadelphia Country Club honoring him as one of the charter members of the Society, for his long standing loyalty and service to the Society and for his contributions to Radiology, especially in the field of radium therapy.

In 1950 a dinner was given in honor of Dr. Bernard Widmann who had been elected President-Elect of the American Roentgen Ray Society and to Dr. Barton R. Young who had been elected Secretary of the American Roentgen Ray Society. At the Mid-Winter Conference of Radiologists in Philadelphia a Pioneer Luncheon was held which was addressed by Dr. Pfahler who gave a very interesting talk on the early history of radiology.

In 1952, a dinner was given in honor of James L. Weatherwax who was the pioneer radiological physicist in Philadelphia and to whom so many of us are indebted for his assistance and instruction and calibration of our roentgen apparatus.

The discovery of the roentgen rays having occurred fifty years previously—1895, the Society voted in September, 1945, to celebrate this anniversary by placing an exhibit in the College of Physicians. Dr. Pfahler and the Librarian of the College, Mr. McDaniel had charge of the exhibit.

At the December meeting, 1945, an invitation was received from the American-Soviet Society to attend their annual meeting. No one attended.

Three Postgraduate courses were conducted by the Society in 1945, 1947, and 1948. These courses were co-sponsored by the American College of Radiology. First preference for enrollment was given to those diplomates of the American Board of

Radiology with a record of military service, second to those diplomates without a military record, and third preference was given to non-diplomates with no military service. The courses were enthusiastically received and at each course a full attendance was obtained. Members of the Society and distinguished teachers of radiology from other cities participated in the instruction.

In 1948 an amendment to the Constitution was passed which required certification of the American Board of Radiology as one of the requirements for election to active membership.

Starting with the December meeting, 1948, a refresher course in Radioactive Isotopes was given by Dr. S. Reid Warren. Refresher courses have also been given, since then, by other members of the Society.

The Golf Tournament at the Spring Outings of the Society has been held annually. The cup for the members winning the tournament was donated by Dr. Joseph E. Roberts, a past-president of the Society. In 1951 a trophy was voted to be given to the manufacturers' representative having the lowest score.

The list of presidents of the Society, 42 in number, is a matter of record and as the time is short I shall not read them. However I asked the President, Dr. Chamberlain to bring the President's gavel presented by Dr. Pfahler and I suggest those members and guests who have not seen it, inspect it either here or at the dinner. On the case in which it lies, the list of Presidents is engraved.

An associate membership was instituted in 1923. According to the amendment to the Constitution, "Physicists, teachers and others whose vocation tends to improve the practice of roentgenology may be elected to associate membership." Mr. James L. Weatherwax was the first elected in this category. Beside Mr. Weatherwax others in this group who have contributed papers to the programs of the Society and also have made contributions in roentgenological journals were Dr. S. Reid Warren, Jr., who gave the first Refresher Course on Radioactive Isotopes when these courses were instituted, and Dr. George C. Henny who has also contributed much to the Society. Especial mention should be made of the associate members not physicists, Dr. Oscar V. Batson in anatomy, Dr. Leroy M. Ennis in dental roentgenology, and Dr. Goerge A. Hahn in treatment of uterine carcinoma.

When the meetings of the Eastern Section of the American Roentgen Ray So-Society, usually held in mid-winter in Atlantic City, were discontinued, Dr. David R. Bowen took a great interest in the formation of what is now the Mid-Winter Conference of Eastern Radiologists. He was the Philadelphia representative on the first committee and played a leading part in securing the cooperation of the four other local participating societies from Washington, New York, Baltimore and New England. The Philadelphia Roentgen Ray Society has held the meeting and furnished the program every fifth year except during the years of World War II when the conferences were omitted.

On reading the minutes one is impressed by the foreign speakers who addressed the Society.

Dr. Robert Knox, London, Oct. 3, 1923, *Diagnosis of Renal and Gallbladder Calculi.*

Drs. Masao Tsuzuki, Tokio, Japan and Daniel Ledesaca, Manila, P.I.

Dr. Cestion, France, 1919, *The Use of Radium in the Treatment of Salpingitis.*

Dr. Jose A. Saralegui, Professor of Radiology & Physical Therapy, Medical College of Buenos Aires. Nov. 6, 1925.

Dr. Jacques Forestier, France, Feb. 4, 1926. *Roentgen Examination of Organic Cavities with Injections of Iodized Oil.*

Dec. 13, 1934. *Some Points of Technique and Diagnosis in the Use of Iodized Oil in Chest Examinations;* Second paper: *The Early Stage of Spondylitic Ankylosis.*

Dr. Arthur Schüller, Vienna, June, 1926. *Lesions Involving the Skull.*

Dr. Arthur Haenisch, Hamburg, Germany, Oct. 1, 1931. *Safety Film.*

Prof. H. Coutard, Paris, France. Oct. 1,

1931. *Carcinoma of the Larynx.*

Prof. Ellis Berven, Stockholm, Sweden. Oct. 1, 1931. *Carcinoma of the Tonsil.*

Prof. A. Lacassagne, France, April, 1936. *A Hormonal Pathogenesis of Adenocarcinoma of the Breast.*

Dr. C. Wesley Prowd, Vancouver, B.C., Canada.

Dr. Zeides des Plantes, Utrecht, Holland, Oct. 1937, *Planigraphy and the Subtraction Method.*

Dr. Carlos Santos, Prof. of Radiology, Lisbon, Portugal, Jan. 17, 1946. *Physiological and Technical Fundamentals of Stereoscopic Fluoroscopy Especially Adapted for the Removal of Foreign Bodies.*

Dr. Nils Westermark, Dec. 16, 1946, Stockholm. *Some New Roentgen Studies of the Circulation with Special Reference to the Pulmonary Artery.*

Dr. James F. Brailsford, 1950, England.

Many well-known and distinguished radiologists from the United States have addressed the Society but to enumerate them all is impossible in the time allotted for this paper.

Members who have held office in national organizations:

President: American Roentgen Ray Society: Goodspeed, Leonard, Pfahler, Pancoast, Manges, Bowen, Bromer, Widmann; *Radiological Society of North America:* Jackson, Pendergrass; *American College of Radiology:* Pfahler, First President, 1923, Pancoast, Chamberlain, Pendergrass; *American Radium Society:* Pancoast, Pfahler, Newcomet; *American Board of Radiology:* Pancoast—First President, Manges served 1½ years as Vice-President and would have been elected President had he survived.

Chairmen Section of Radiology, American Medical Association: Pancoast, Bromer, Widmann.

President Pennsylvania State Medical Society; Speaker of House of Delegates, American Medical Association: Borzell.

First Inter-American Congress of Radiology: Pancoast.

Fifth International Congress of Radiology: Pfahler, Vice-President.

Third International Cancer Congress: Pfahler, Honorary Vice-President.

No history of radiology in Philadelphia would be complete without mention of the service performed by the Society in connection with what might be called related medical and lay activities. During the many years of its existence, the Medical Economics Committee and the Hospital Advisory Committee have devoted much time to the relationship of radiology and radiologists to the hospitals, the Blue Cross and to the Blue Shield with consequent action by the Society. Suggestions were made for proper relationship of radiologists to the interpretation of mass roentgen chest surveys; the Society cooperated with the Franklin Institute in arranging an exhibit on roentgen rays in the Museum of that institution. Close relationship was established with the Philadelphia Society of X-ray Technicians and also with the American Registry of X-ray Technicians; adjustment of fees for compensation for roentgenologic examination was undertaken; the Society cooperated with the Department of Public Instruction of the State in regard to requirements of private or lay schools for X-ray technicians; the Board of Health was asked to investigate the indiscriminate use of fluoroscopes for fitting shoes in stores, which was being done without adequate supervision; the Society cooperated with the Philadelphia Board of Education in suggesting the curriculum for the preliminary studies of X-ray technicians in the city schools. During the early years of World War II, the Society cooperated with the Army Medical Service in supplying radiologists for the interpretation of the chest films of inductees into the Service.

In 1951 recommendations were made by the Society to the Philadelphia Civil Service Commission for necessary qualifications for applicants for positions as x-ray technicians. The Civil Service Commission replied that they were grateful for the suggestions made and asked the Society to appoint a panel of radiologists to prepare

a master list of questions for written examination for such positions. This was accordingly voted.

In 1940, the Pancoast Memorial Lecture was voted by the Society and the first lecture was given in 1941 by Dr. George W. Holmes of Boston, an old friend of Dr. Pancoast. The list of Pancoast Lecturers previous to this meeting follows:

1941 Dr. George W. Holmes, *Roentgen Diagnosis and Treatment of Primary Pulmonary Neoplasm.*

1942 Dr. Lawrence Reynolds, *New Investigations of Radiation Effects and Their Clinical Applications.*

1943 Dr. Dallas B. Phemister, *Disturbances Arising from Interruption of Circulation in the Skeletal System.*

1944 Dr. Edward B. Benedict, *Correlation of Gastroscopic and Pathological Findings in Diseases of the Stomach.*

1945 Dr. Ross Golden, *Basic Physiology of the Small Intestine.*

1946 Dr. Robert S. Stone, *Nuclear Fission and Medicine.*

1947 Dr. Leo C. Rigler, *Limitation of Roentgen Diagnosis.*

1948 Dr. Gioacchino Failla, *Dosimetry of Radioactive Isotopes.*

1949 Dr. W. Edward Chamberlain, *A Basic Philosophy for the Radiation Therapist.*

1950 Dr. Eugene P. Pendergrass, *X-ray Diagnosis of Silicosis.*

1951 Dr. Wendell G. Scott, *Development and Application of Angiography and Aortography in the Diagnosis of Heart Disease.*

1952 Dr. Charles L. Martin, *Treatment of Cancer of the Face, Mouth and Neck with Irradiation.*

1953 Dr. Richard Schatzki, *Some Aspects of Dysphasia.*

Some mention should be made of radiology in Philadelphia other than pertains to the history of this Society. Radiology has had in some centers a growth in other specialties. This has not been true to any appreciable extent in this city. Technique and interpretation have been retained by the radiologists. What was lost in the early days in regard to radium therapy may, possibly, be ultimately regained. I know of no hospital where interpretation has been taken over by the genitourinary surgeons or by the neurosurgeons and neurologists. I well remember the remark of Dr. Pancoast in the early days of encephalography to the effect that radiologists must learn interpretation of neurological air studies or the neurologists and neurosurgeons will do their own interpretation. No pediatrician trained as a specialist in diagnostic pediatric roentgenology has been appointed to a hospital position. In other cities where this has happened, the staff of the hospital has been forced to refer their therapeutic cases elsewhere or appoint a therapeutic radiologist. This Society, and the national societies, have had frequent papers and symposia on pediatric radiology on their programs which have aided in stimulating younger men to enter this specialty within a specialty.

I have omitted the history of any events of the last two years which are fresh in the memory of most of the members of the Society. In closing, I wish to emphasize the part played by Dr. Pancoast in the formation of this Society, and his influence and the impact of his character on all of its members throughout his life. I suggest that all of us older members reread, and the younger members read, his *Reminiscences of a Radiologist* published in the American Journal of Roentgenology and Radium Therapy, 1938. I quote Dr. Percy Brown who wrote of Dr. Pancoast, "His face was turned to but one objective—better radiology at his own work-bench and at those of each of his assistants and students. A man whose intellectual honesty permeated his being as roentgen rays permeate the screen, he despised mental side-stepping and ignored collateral subterfuge. His love of truth was intense." I wish again to thank the Society for the honor of participating in this lecture and for the opportunity to join in paying honor to the memory of Dr. Pancoast.

Bryn Mawr Hospital
Bryn Mawr, Pennsylvania

EVOLUTION OF ROENTGEN FILM*

By ARTHUR W. FUCHS
ROCHESTER, NEW YORK

"Of especial interest in many ways is the fact that photographic dry plates show themselves susceptible to x-rays. We are thus in a position to corroborate many phenomena in which mistakes are easy, and I have, whenever possible, controlled each important ocular observation in fluorescence by means of photography."

THUS, Röntgen's original communication[37] indicated the importance of the photographic plate as a means of *recording* the roentgen ray image and opened the way to a new science—roentgenography. He demonstrated this point by showing the first roentgenogram, one of Mrs. Röntgen's hand, and also the first one taken through metal, which showed a compass card and needle enclosed in a metal case.

Roentgenography is photography.† Like photography, it may use visible light (from the fluorescent screens), or it may use roentgen radiation itself, which differs from visible light only in wave length.

Since roentgenography makes use of photographic emulsions as recording media, the story of roentgen film actually reaches back into the beginning of photography itself when it was observed that certain salts of silver responded to the action of light.

THE BEGINNINGS OF PHOTOGRAPHY

In the 18th century it became known that some silver compounds blackened when exposed to light.[27,30] In 1727, a German chemist, John H. Schultz, discovered that a paste of silver carbonate or chloride mixed with chalk became dark when it was exposed to light in a glass tube. After stencils of letters were placed on the tube and the material exposed to sunlight, black lettered images were seen when the stencils were removed. However, these images were only transient; since he knew of no way to make them permanent, the areas originally protected from light eventually darkened.

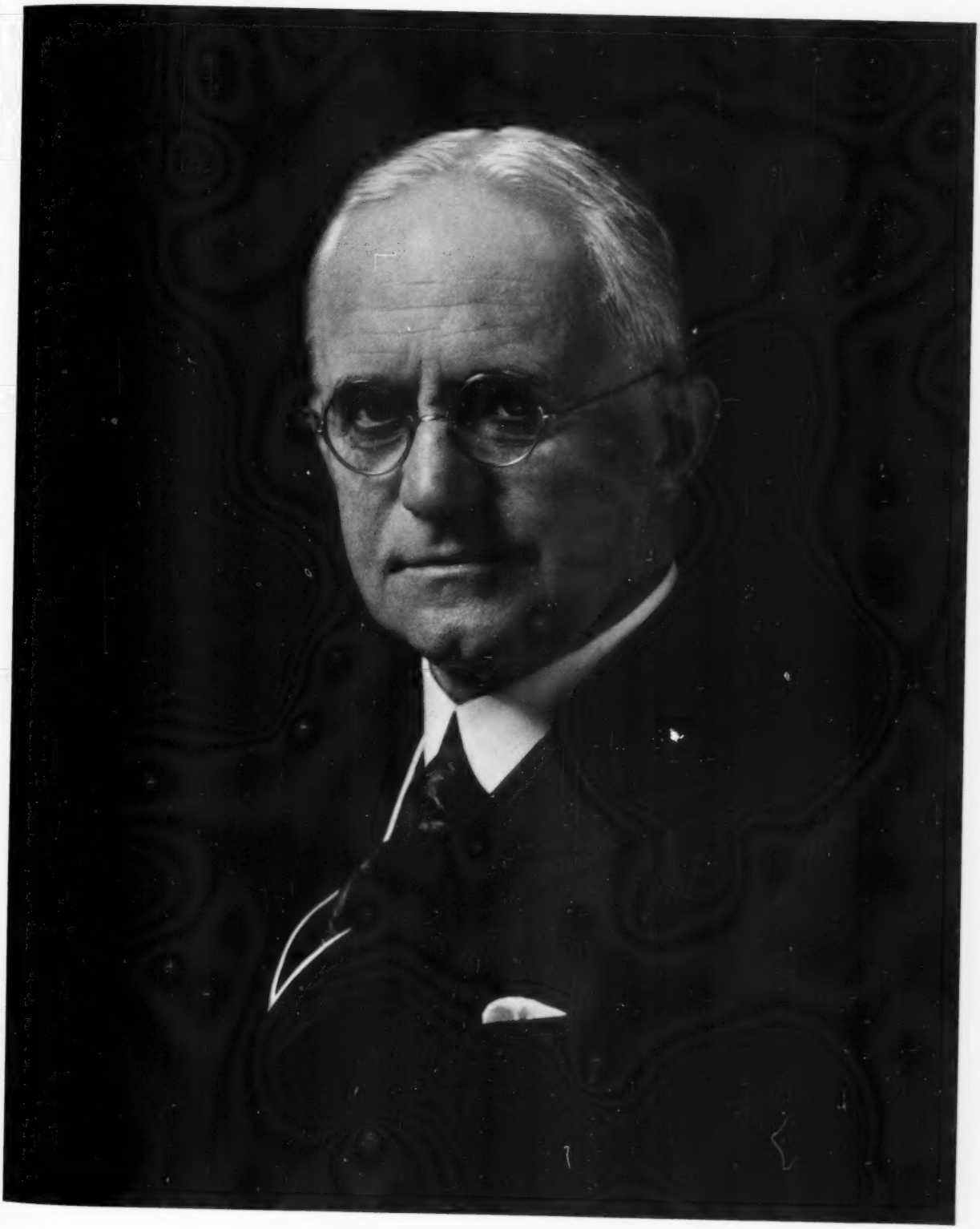
In 1802, Thomas Wedgewood and Sir Humphrey Davy recorded silhouettes on glass by contact printing on paper coated with silver chloride. A crude camera was made in 1816 by Joseph N. Niepce from a jewel box in which a lens from a microscope was inserted. With this device, he secured an image. None of the images obtained could be made permanent.

William Henry Fox Talbot, an Englishman, exposed silver chloride paper in a camera obscura to secure a visible image which was made permanent by treatment with sodium chloride. Talbot made an important discovery in 1840, when he found that he could develop a latent image after exposure of the silver layer. He obtained a negative image and by printing on sensitized paper was able to obtain positive images. Talbot became the inventor of the *negative-positive* method of photography. It is interesting to note that Sir John Herschel, an outstanding scientist of the period, wrote Talbot under the date of February 28, 1839, using the coined world "photography"—drawing with light—in referring to Talbot's work. He also coined the terms *negative* and *positive* in reference to photographic images. The word "photography" then was acquired by the vocabulary of all languages.

In 1819, Herschel discovered the solvent action of hypo (sodium thiosulfate) on silver chloride. However, the Rev. J. B. Reade was the first (1837) to use sodium thiosulfate to dissolve the unexposed silver salts remaining in the photograph. This treatment prevented the possibility of the image darkening upon further exposure to light.

† Photography is the art or process of obtaining images on sensitized surfaces by the action of light or other radiant energy. (*Encyclopedia Americana*, 1955).

* From the Medical Division of the Eastman Kodak Company, Rochester 4, New York.



GEORGE EASTMAN
1854 · 1932

The Frenchman, Louis J. J. Daguerre, recorded images (1839) on plates covered with a silver salt that had been fumed with iodine to form a layer of silver iodide. Long exposures of these plates in a camera produced faint, unsatisfactory visual images. One day he placed one of the exposed plates in his cupboard. Upon removing the plate at a later date, he found that there was a well-defined positive image on the plate. Some mercury had been spilled in the cabinet and its fumes had "developed" the image completely. The unexposed silver iodide was removed by a solution of sodium chloride. Daguerre thereby discovered the phenomenon of *development.*

Paper negatives were used up to this time, but the grainy paper structure was reproduced on the prints. To overcome this condition, C. F. A. Niepce de St. Victor in 1847 coated glass with an albumen emulsion containing silver iodide. Gallic acid was used for developing and resulted in a good quality image of fine grain.

Frederick Scott-Archer, in 1851, published the details of a process wherein wet collodion was used as a binder for the silver salts and coated on glass. The exposure was made before the collodion dried. It soon superseded all other processes. However, the method was laborious and inconvenient. Many variations of the collodion process were tried but none was too satisfactory. Hence, various attempts were made to find a method of coating a plate that could be dried and perhaps stored until used.

Invention of dry plate. The invention of the *dry* plate, using an emulsion of silver bromide in gelatin, by Richard L. Maddox of England in 1871 served as the basis for modern photography. Its speed and stability was improved by J. Burgess, who in 1873 manufactured the first practical dry plate with a washed emulsion. Also, in 1873, H. W. Vogel discovered that such plates, normally sensitive only to blue and violet light, could be made sensitive to all colors by the addition of certain dyes.

Dry plates were found to be several times faster than the wet plate and were soon manufactured in several countries. At first, dry plates were coated by hand. The first mechanically coated glass plates were made in 1879 by George Eastman who had invented a plate-coating machine. Another product called *American Film* was introduced by Eastman in 1885. This was a stripping film which used paper as a temporary support for the emulsion. After exposure and processing, the paper was stripped away leaving a thin transparent "film" from which prints could be made. At this time also, Eastman began the manufacture of paper sensitized with an emulsion for use in cameras and called Eastman *Negative Paper.* After exposure and development, the paper was made transparent for printing by chemical treatment. In 1889 this firm introduced a flexible transparent base of nitro cellulose coated with a sensitive silver halide emulsion. This product served to advance photography greatly. Thenceforth, photosensitive materials became progressively more efficient as more knowledge concerning the science of photography accrued. Thus, the stage was set for one of man's most important discoveries wherein the photographic emulsion played a dominant role.

BIRTH OF ROENTGENOGRAPHY

In the course of Röntgen's earliest experiments, he found that a photographic "dry plate" was exposed by the "new rays," thus opening to the world a vast field of endeavor—roentgenography.

One of the early problems in the evolution of roentgenographic emulsions had to do with determining just how the roentgen rays produced the image on the photographic plate. Was the effect photoelectric or photochemical, and what was its nature? This subject caused a great deal of speculation and some of the theories advanced are interesting and, in some instances, amusing. In Röntgen's original paper[37], he pointed out that:

"It is still open to question whether the chemical effect on the silver salts of photographic plates is exercised directly by the x-rays.

It is possible that this effect is due to the fluorescent light which . . . may be generated on the glass plate, or perhaps in the layer of gelatin. Films may be used just as well as glass plates."

Röntgen's observations on the roentgen-ray fluorescence of various materials gave rise to many views concerning the effect roentgen rays had on the dry plate. Mr. Chapman-Jones remarked in *Photography*, 1896:

"We may well ask whether the x-rays produce the developable action in gelatino-bromide plates by their direct action or by a secondary action. Is, for example, the plate sufficiently fluorescent to be excited by the x-rays into luminosity, or if not to luminosity, perhaps the excitation results in the production of invisible (say ultraviolet) rays at the surface of the plate, and then these affect it as we know they do. If this kind of secondary action takes place, we may not have here sensitiveness to any new force but merely the production of the new force of radiations which we know are photographically active, and we shall then have no new fundamental principle to add to our knowledge of photography. On the other hand, light is only a form of energy; it is stated that the developable condition can be induced by other forms of energy, such as pressure, contact with certain chemical bodies, heat, etc., and if the x-rays act directly in producing the developable condition, we shall have to add another form of energy to those we know to possess this power. . . Photography is already the recorder of facts; it will, perhaps develop eventually into being the recorder of forces."

Some believed that the effect on the emulsion was produced by "phosphorescence" or action of some unknown kind at the back of the plate. This view was supported by an experiment of Dewar upon ammonium platinocyanide crystals at low temperatures. This salt, ordinarily fluorescent in visible light, lost this property when immersed in liquid air, but when exposed to roentgen rays, fluoresced freely. This condition suggested that whatever the nature of the roentgen rays, they were convertible into visible light; hence, the glass support may have contributed something in producing the image. In 1898 this speculation was disproved by the fact that emulsions supported on nonfluorescent bases, including paper, had been found equally effective.

At first, development of the image was believed to begin at the back of a plate; but this was disproved by workers who exposed an emulsion stripped from the glass. The exposure action was thought to be due almost entirely to fluorescence within the emulsion aided by the fluorescence of the glass support. Some even stated that the roentgen rays exerted no *direct* action upon the sensitive plate!

These controversies have been gradually settled in modern investigations, which have shown that the action of roentgen rays is similar to that of light, in that the radiation is primarily responsible for exposing the silver halide grain. Any fluorescence of the emulsion or support is very slight and does not produce a significant image. These remarks apply, of course, only to direct work with roentgen rays; in screen work it is the light from the screen which produces the exposure.

PIONEER CONDITIONS

The photographic journals were the media for discussion of the roentgen rays following their discovery. In fact, roentgenography was considered as a new specialty in the field of photography. Most of the workers who were actively engaged in making roentgenograms were photographers, or physicians who practiced photography as a hobby. "Roentgen studios" conducted by photographers sprang up in America and Europe, advertising the fact that they were conducting a business in "Roentgen photography" and that appointments could be made for "x-ray sittings." Naturally the medical profession was canvassed, and the majority of the work done by these studios was essentially medical or surgical in character. Occasionally, curious persons requested roentgenograms of various opaque objects such as pieces of sculpture, jewelry, pearls, dia-

Fig. 1. Reproduction of a photograph appearing in *The Western Electrician* for August, 1896 of the laboratory of Wolfram C. Fuchs of Chicago, Illinois. Note early tubes, coil equipment and examining table used when making roentgenograms.

monds, metal castings, mummies, and other objects of like nature—a prefigure of industrial radiography of modern times.

Some of the pioneer workers achieved impressive results with no more elaborate equipment than an induction coil, a gas tube, and a photographic dry plate—a combination which required exposures of one or more hours to make a roentgenogram of the hand. Obviously, the early roentgenogram lacked density and contrast. As a matter of fact, regardless of the length of the roentgen ray exposure, after-treatment of the roentgenograms often was necessary in order to make satisfactory prints from them. Since the early roentgen worker followed the procedure practiced by the professional photographer, positive prints of roentgenograms were usually made on a photographic paper which possessed considerable contrast. Moreover, the density and contrast in the print could be increased, thereby enhancing details that were only faintly visible in the plate. The prints were often gold-toned to yield a pleasing sepia positive.

Initial plate problems. Photographic dry plates were slow to roentgen rays in 1896 and 1897, and there was a real need for greater roentgenographic sensitivity. This fact led experimenters to try every conceivable method of increasing the emulsion speeds. Geissler of Bonn, Germany, in April 1896, advocated immersion of the dry plate, before exposure, in solutions of iron chloride, uranium nitrate, or an extract of cuba wood, to obtain a better image. These results were inconclusive. Others soaked the plates in solutions of fluorescent salts, but this method usually resulted in a loss of sensitivity and the production of extreme fog which made the plates worthless. Impregnation of the emulsion with roentgen-ray fluorescent salts was also attempted; in fact, an English plate manufacturer, B. J. Edwards and Company, began to produce plates in May, 1896, the emulsion of which contained a fluorescent salt of this type recommended by Sir Oliver Lodge. This product was called the *Cathodal Plate.*

The most successful method, however, was the employment of the fluorescent screen which will be discussed later. Mention should be made of the early observation that the sensitivity of an emulsion when subjected to the fluorescence from

Dr. Schleussner's Trockenplatten
von bekannter Güte, Zuverlässigkeit und Gleichmässigkeit;
* * Röntgenplatten von vielen Autoritäten empfohlen,
Momentplatten von höchster Empfindlichkeit, speciell für wissenschaftliche Zwecke,
Orthochromatische Platten, ohne Gelbscheibe verwendbar,
Abziehplatten für Lichtdruck,
Celluloidfolien (Films) flachliegend,
Rollfilms f. (Spulen) f. sämtl. Tageslicht-Cameras u. Rollcassetten
empfiehlt die
Trockenplattenfabrik auf Aktien
vorm.
Dr. C. Schleussner,
Frankfurt a. M.
Bezug ab Fabrik oder durch die Händler.

Fig. 2. A Schleussner advertisement (1899) listing roentgen plates and celluloid films.

screens is dependent largely upon the *color* of the fluorescent light emitted by the screen. Sensitization of the plates before exposure with a four-minute immersion in a bath of silver erythrosine was advised. Such sensitized plates, it was said, required only one-ninth the exposure of ordinary, directly exposed plates. The most suitable plates for roentgenography seemed to be the English brands, *Cadett Lightning*, *Paget xxxxx*, Imperial (May, 1896), and *S. W. Roentgen Plates*, Sandell Works Co.; the French, *Lumière* (1896), and the American, *Cramer C Plate* and the *Carbutt X-ray Plate* (1896).

A constant query in 1896 was, "What sensitive emulsion is best for roentgen-ray work?" The answers in most cases were quite contradictory, as every plate on the market was claimed to be the most sensitive.

The prevailing types of emulsions recommended or used in early roentgenographic work were: the orthochromatic, for it was sensitive to the yellow-green fluorescence of the barium platinocyanide screen; the collodion, or wet emulsion, which was but slightly affected by roentgen rays; mixtures of silver bromide gelatin emulsions, with silver iodide or chloride, which were fairly satisfactory; and the pure silver bromide gelatin emulsion. The common agreement was reached that the emulsions, irrespective of their color sensitivity, should be very much thicker than those employed for pictorial photography.

The reduction in the time of exposure was one of the early problems to be met, for it was realized that if this "new photography" was to be of any value, prolonged exposure was entirely out of the question. Prior to May 1901, no very startling improvement was made in the manufacture of plates, and the consensus was that any good brand of very fast photographic plate gave results in keeping with the best efforts of the roentgen-ray workers.

The recommendation usually advanced by many of the best workers was to use a plate with which the roentgenographer was familiar. This recommendation was so widely accepted that it tended to delay whatever efforts manufacturers were willing to make in producing a special roentgen-ray emulsion. As long as the consumer

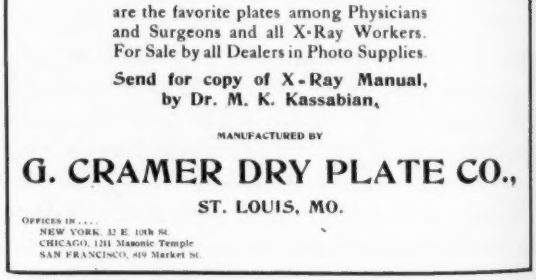

CRAMER'S
X-Ray Plates
are the favorite plates among Physicians and Surgeons and all X-Ray Workers.
For Sale by all Dealers in Photo Supplies.
Send for copy of X-Ray Manual, by Dr. M. K. Kassabian.
MANUFACTURED BY
G. CRAMER DRY PLATE CO.,
ST. LOUIS, MO.
OFFICES IN....
NEW YORK, 32 E. 10th St.
CHICAGO, 1211 Masonic Temple
SAN FRANCISCO, 819 Market St.

Fig. 3. Early Cramer advertisement (1903) of a very popular roentgen plate of the time.

was content with the photographic plate, it was apparently thought advisable to let well enough alone.

One of the problems in development was to obtain adequate density. The roentgenograms were apt to be thin and lacking in contrast. To overcome this difficulty and at the same time to decrease the time of exposure, multi-emulsion coated plates, and gelatin or celluloid films were made, for it was claimed that greater detail and contrast was obtained as compared to a single-coated plate or film. Special plates and films also were coated on both sides of the support. The rays passed through the support and, in the case of film, affected the emulsion on both sides to the same degree so that the image on one side reinforced that of the other. This method in use today, doubled the density of the image and greatly improved the roentgenogram's diagnostic value.

EARLY PROCESSING METHODS

In the early days the roentgenographer developed roentgenograms and prints by means of the old "four bottle" photographic method, covering his sensitive material first with a solution containing the developing agent, preservative, accelerator, and then the bromide. As development proceeded he added a little of the solution from one or another of the bottles containing the essential components as his judgment dictated, until development was completed. He thought that by doing so he was thus able to bring out the anatomical detail desired. The most prevalent method of increasing the density of the image was through after-treatment (intensification) of the negatives, and many of the leading roentgen workers of that time resorted to that practice.

ILFORD
X-RAY PLATES
SPECIALLY PREPARED FOR RADIOGRAPHIC WORK
Supplied in ORDINARY packing, DOUBLE ENVELOPES, or in DOUBLE WRAPPERS.
X-RAY FILMS specially wrapped for Dental work.
ILFORD, Limited, ILFORD, LONDON, E.

Fig. 4. Advertisement (May, 1912) featuring the Ilford roentgen plate; also mentioned are specially wrapped dental films.

Wratten
X-Ray Plates

A Wratten X-Ray Plate requires less exposure for a given subject than any other X-Ray Plate.

This is because the emulsion of the Wratten X-Ray plate contains a salt of a very heavy metal.

This salt prevents the powerful X-Rays from passing through the emulsion without serving any useful purpose.

Wratten X-Ray Plates have not been increased in price. Their use means a gain in quality and a saving in cost.

Use Wratten Plates for all your X-Ray Exposures.

Kodak Limited (Wratten Division),
Kingsway, London, W.C

Fig. 5. Advertisement (1914) of a unique type of roentgen plate called the Wratten X-ray Plate which contained a heavy metal salt in the emulsion.

The roentgenographers were used to the complicated and nonstandardized photographic methods of those days, and accepted the attendant inconveniences with little thought of possible simplification. Typical of the ingenuity and intelligence brought to bear on these problems is the experience of Dr. E. R. Corson of Savannah, Georgia, described in one of his early papers:

"In my earlier x-ray work I intrusted the developing and printing of plates to a professional photographer; but I soon found that, unless I had him entirely at my beck and call it was impossible to do any systematic work. There were certain differences in photographic technique to produce prints from negatives, such, at any rate, as I conceived they should be, that

he had much to learn, just as I had to learn the entire process, having had no previous knowledge or experience in photographic work. I found that what the professional would regard as a fine negative did not always give a satisfactory print, one that gave the deep and essential details without the superficial ones and the flesh. Thus I found that every negative had to be intensified just as regularly as the plate was developed and fixed. There were further difficulties to be overcome in printing which did not exist in ordinary photographic work. . . I have used the Carbutt x-ray plates as well as the Seed's extra-rapid plate, No. 27. This latter plate is cheaper and just as good as the Carbutt, and I use it now entirely. I have found that the Eastman hydrochinon developing powders are as good as, perhaps better than, any other developer, and very handy. I use a chrome-alum fixing bath as given by Carbutt and Carbutt's formula for the intensifier. . . . For a printing paper I use solely the "Carbon matt Velox," which has many advantages over all other printing papers, at least to produce prints as I conceive they should be."

All types of developers were employed in the days of the glass plate—no two were alike. The quantities of chemicals employed in the various formulas were not standard, and development was entirely empirical with each roentgen worker. The lack of precision was nicely summed up by Dr. Preston Hickey who said (1907) that any developer when handled properly would develop a plate!

THE QUEST FOR SHORT EXPOSURES

Fluorescent screens. While improvements in tubes and apparatus were being rapidly made, the photographic emulsion had not kept pace. It remained for Thomas Alva Edison to again call attention to the problem by his work with fluorescent screens.[11,15]

Edison's intense interest in scientific advances compelled him to plunge into the new field of roentgenology with tremendous energy and enthusiasm. He developed and improved tubes, apparatus, and fluorescent screens.

The fluoroscopic screen of 1896 was a crude affair—flimsy, unstable, and expensive. Consequently, there were many who were advised to make their own fluoroscopic screens in order to improve fluoroscopic detail. The screen images revealed only a suggestion of detail in the body structures; they were in effect crude silhouettes. These diffuse images usually were obtained when using non-focus tubes; but, with the advent of focus tubes, the use of the fluorescent screen gained greater impetus because sharper images were possible, although they were far from ideal.

From January to March, 1896, Edison tested some 8,500 different materials in his effort to build a new incandescent lamp. In the course of this work, 1,800 substances were found to be fluorescent. Of these, calcium tungstate had approximately 6 times more intensity than barium platinocyanide. He recommended the use of calcium tungstate for roentgen fluoroscopic screens in March, 1896.

Professor Michael Pupin of Columbia University had been keenly interested in the work conducted by Goldstein of Germany on discharge-tube phenomena; consequently, he was about the only person in the New York area who had equipment adequate to produce roentgen rays early in 1896. Pupin immediately began to study this new radiation and did a tremendous amount of experimental work. In examining the large numbers of patients that physicians sent to him, he made every effort to increase the efficiency of his apparatus so that he could shorten the exposure.

In his autobiography,[35] Pupin wrote:

"My good friend, Thomas Edison, had sent me several fluorescent screens, . . . I decided to try a combination of Edison's fluorescent screen and the photographic plate. The fluorescent screen was placed on the photographic plate and the patient's hand placed on the screen. . . The combination succeeded even better than I had expected. A beautiful photograph was obtained with an exposure of a few seconds. . . . That was the first x-ray picture obtained by that process during the first part of February, 1896. . . "

Further work on the fluorescent screen tended to overemphasize the idea that all roentgen-ray work could be satisfactorily performed by means of the fluoroscope. This trend was influenced in some degree by a telegram given wide publicity, which Edison sent to Lord Kelvin in March, 1896:[15]

"Just found calcium tungstate properly crystallized gives splendid fluorescence with Roentgen rays, far exceeding platinocyanide, rendering photographs unnecessary."

Subsequent events, however, have proved the fallacy of this hasty assumption.

While the more brilliant visual image of Edison's new fluorescent screen of calcium tungstate was some improvement over the earlier type of screen, it still had many disadvantages. In the examination of the thicker parts of the body, the image was difficult to decipher because of its grain; detail, even in the thinner parts, was almost impossible to discern. On the other hand, the photographic plate offered not only a permanent record, but a clearer one with greater definition and more minute detail than the image seen on the fluoroscopic screen. Further, the effect of the roentgen rays on the sensitive plate was cumulative so that an image only faintly perceptible on the fluoroscopic screen could be more satisfactorily registered on a plate by merely prolonging the exposure. In this way roentgenograms of an adult pelvis could be made, whereas a detailed image could not be observed directly on the fluoroscopic screen.

Max Levy, a German, was apparently the first to recommend and use, in 1897, a *double-coated* film sandwiched between two fluorescent screens.

It is strange that although screens for intensification purposes were introduced very early in the history of roentgen rays, yet they seem to have been dropped out of use for many years. The reason perhaps was that those old screens possessed an extreme amount of afterglow and excessive grain due to the use of very large-sized

Fig. 6. The first roentgenogram for which a fluorescent screen was employed for intensifying purposes was made by Professor Pupin in February, 1896.

fluorescent crystals. Such crystals always gave the brightest fluorescence but caused a granular appearance both in the fluoroscopic image and roentgenogram, obscuring detail. About the only examinations in which they were extensively employed were those of the gastrointestinal tract, spine, hip, and skull, where the increased density and possibility of movement necessitated a short exposure. At that time some workers found that roentgenograms made of the kidneys without a screen gave a negative diagnosis but those made with screens rendered calculi visible. Others obtained splendid roentgenograms of calculi without the aid of screens. The failure to obtain better results in some instances was no doubt due to the extreme exposure and great penetration which was then being advocated.

Progress in emulsion making. All through this early period, American researchers experimented extensively with emulsions. The first plate strictly for roentgen-ray purposes was made by John Carbutt co-opera-

Amateurs and Professionals
SHOULD USE
THE OLDEST AND BEST
THE Carbutt Plates, Films AND Specialties
USE • • •
UNDOUBTEDLY HAVE THIS DISTINCTION
"Eclipse" for Portraiture and Hand Camera exposures, and you have a Plate that has Rapidity with Quality.
Orthochromatic Sen. 27, about equal in speed to the Eclipse: gives correct color values.
X Ray Plates for making Radiograph Negatives. These plates have the special quality of absorbing the X Rays of a Crookes' Tube, allowing of short exposures. They are used by Prof. A. W. Goodspeed of the University of Pa., who has produced fine results with exposures as short as 4½ seconds, Nikola Tesla and Dr. William J. Morton, of New York, and many other Scientists also use them.
For View Photography use
Ortho Sen. 23, also for photographing Flowers, Architecture, etc. Can be used with or without a Color Screen as circumstances necessitate.
B Sen. 16, for Landscape and Architecture. Unparalleled latitude of exposure makes it the "Standard" for beginners.
Lantern Plates have no equals for Brilliancy and Uniformity.
J. C. Developing Tabloids. Put up in boxes containing 96 Tabloids, enough to develop 8 to 12 dozen 4x5 Plates. Price, 75 cents. Mailed, postpaid, on receipt of price. Sample box, 10 cents.
FOR SALE BY ALL DEALERS.
Send to Factory for full list of PLATES, FILMS and SPECIALTIES.
MANUFACTURED BY
JOHN CARBUTT,
KEYSTONE DRY PLATE AND FILM WORKS.
Wayne Junction,
PHILADELPHIA.

FIG. 7. An early Carbutt advertisement (1896) for the first specially prepared American roentgen plate.

ting with Professor Goodspeed of the Physical Laboratories of the University of Pennsylvania. This product, called the *Roentgen X-ray Plate*, possessed a thicker and heavier silver emulsion than the usual photographic plate and permitted a radical reduction in the time of exposure. It was tried out on February 11, 1896, at the Maternity Hospital, Philadelphia, Pennsylvania by Professor W. W. Magie of Princeton University. The first exposure was made for Dr. W. W. Keen whose patient had an ankylosis of the finger joints caused by a burn. The exposure was twenty minutes; previously, such projections required exposures of one hour or more.[16,22]

With further improvement in apparatus and roentgen plates, the exposure ranged (April, 1896) from a few seconds for a hand to thirty to sixty seconds for heavier parts. Projections of the trunk, however, were still a problem because exposures were of the order of minutes rather than seconds.

What was then thought to be the proper characteristics of a roentgen-ray emulsion may be summed up in John Carbutt's words (June, 1897):

"It should be of medium sensitiveness, have a good body of emulsion, be capable of absorbing the x-rays, thereby giving more detail and perspective to the bones."

A decade later, Dr. Eugene W. Caldwell seemed to obtain best results on plates of medium or fast photographic speed such as the Hammer *Extra Fast*, the Cramer *Banner*, Seed's *26X or 27*. Plates coated on one side with a double emulsion which were obtainable as non-halation plates offered some advantage. The Hammer *Aurora* was found to give excellent results where it was desirable to use a double-emulsion coated plate to lessen exposure.

Manufacturing defects in plates were beginning to be a critical problem among roentgenologists because the artefacts interfered with diagnosis. During the Meeting of the American Roentgen Ray Society in 1902,* a discussion occurred on this subject with particular reference to diagnoses in cases of calculi. The comments of Wolfram C. Fuchs of Chicago are of interest because they describe emulsion problems that no longer plague the profession:

"I have not found a platemaker yet whose product does not have some defect. After the negative has been developed we find spots all over it. The hardest stones to locate are the small stones. The large ones you can see at a distance. Take a very small stone, as, for instance, in this radiograph (indicating). You can distinctly see the outline of the kidney and the darker shadow in the center, with many darker spots all over. These are even visible to the patient and that is not good. I usually take two plates, one on top of the other, and expose them at the same time with the envelope around them. In this way, while the spots will still show on a plate, yet the spots are not in

* Transactions of American Roentgen Ray Society, 1902, pp. 172–175.

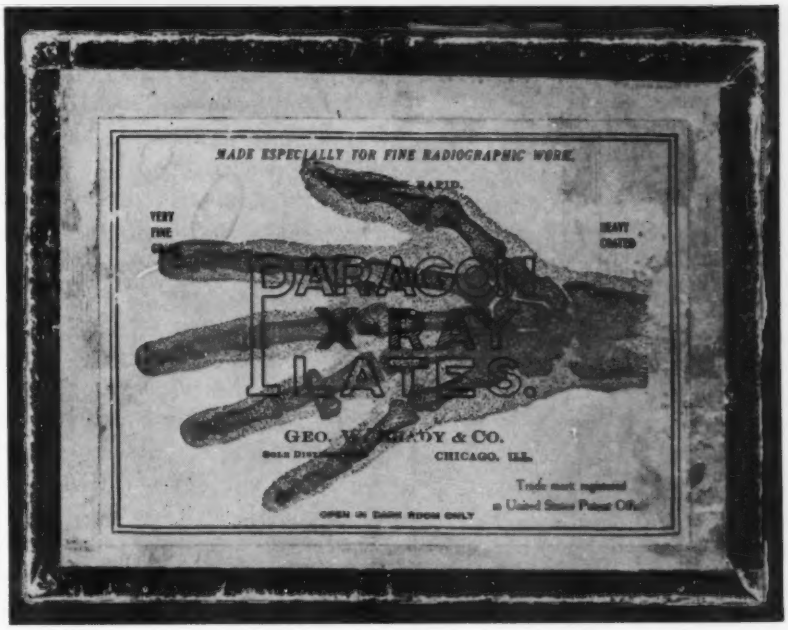


Fig. 8. Label on a box of Paragon X-ray Plates (circa 1914). This was a very popular American brand of roentgen plate used prior to the advent of roentgen film.

the same place on both plates. In that way you can overcome the difficulty of the plate defects. I have spoken to the expert platemakers about this and they recognize it; they try to remedy it, but have not, as yet, succeeded in doing so. I have spoken to them about if for the last three years, but they do not seem to be able to overcome the trouble. I thought at first that it was all my fault, that, perhaps, my developer was bad. I took special pains in the mixing of the different ingredients of the developer, made a perfect solution, and still I found spots and streaks all over the plate. . . . I use a French plate, because I think they are much more sensitive than the American plates. I also take another film with an emulsion on it and put that right next to the plate. This seems to add to the sensitiveness of the plate."

When first supplied (1896), roentgen plates were inserted in lightproof wrappers and sealed, but it was found that the plates deteriorated through interaction between the chemically unpurified paper and the emulsion. The envelopes were later furnished separately and the operator "loaded" his own plates as needed.

It is interesting to note that as late as 1918, a calcium tungstate plate was suggested by Dr. Max Levy and manufactured by the Imperial Dry Plate Company in England. This plate consisted of a glass support coated with emulsion on one side, over which was placed a coat of calcium tungstate crystals. After exposure and before development the plate was held under the water tap to wash off the screen coating. The plate was then developed in the ordinary manner. These plates were expensive to manufacture, showed considerable grain, and were somewhat impractical.

The great demand for roentgen plates led to the manufacture of many American brands such as the *Paragon X-ray Plate*, *Forbes X-ray Plate*, *Cramer X-ray Plate*, *Central X-ray Plate*, *Universal X-ray Plate*, *Diagnostic X-ray Plate*, and many others in England, France, and Germany. In 1912 Eastman introduced the *Wratten X-ray Plate*, which was coated with a heavy silver halide emulsion impregnated with a bismuth salt, the purpose of which was to

EASTMAN
X-Ray Films
EASTMAN X-Ray Films mean—convenience in handling, developing, mailing and filing. They are flexible, light and unbreakable and in quality are at least the equal of the best X-Ray plates make.
The present extensive use of cut films for professional portraiture is proof that the film's advantage over glass plates is appreciated by the photographer—the advantages to the Roentgenologist are even more marked.
For sale by all Supply Houses. Illustrated booklet, "X-Ray Efficiency" by mail on request.
EASTMAN KODAK CO.,
ROCHESTER, N. Y.

Fig. 9. Early Kodak advertisement (April, 1914) of the first single-coated roentgen film.

absorb the roentgen rays and increase the effect on the silver halide crystals in the emulsion. The Seed Dry Plate Company of St. Louis soon offered the *Seed X-ray Plate* to the profession. These plates were well received and were in popular favor for many years until the advent of roentgen film.

ROENTGEN FILMS

In Röntgen's original communication, it was indicated that either plates or films might be used to record the roentgen image. As a consequence, many workers employed whatever photographic material was available for roentgenography. *Eastman Transparent Film—New Formula*, was still being manufactured in 1896 and used for roentgenography in a limited way, just as were other photographic films and plates.

Films used for roentgen-ray purposes in England prior to 1901 were the *Austin-Edwards'* snapshot film and the *Cristoid* made by the Sandell Plate Company. The latter films were essentially gelatin rather than cellulose, and were made of two emulsions—one very rapid and one of regular speed—coated on glass and then stripped off. The films were supplied packed in dark envelopes, were difficult to develop, and much slower than fast *plates*.

Gelatin and celluloid films were not so desirable because of their tendency to curl or crack, but they had this advantage—they were thin and could be used with one or two intensifying screens with a consequent reduction in exposure. Also, they were not subject to breakage as were the glass plates. In Germany this type of film was made for roentgen-ray work about 1896 by the Schleussner Company, such film having a double emulsion on *each* side, making four coats in all. This company also made roentgen plates and was probably the only firm in those days making an emulsion which approached the density, contrast, and speed suitable for roentgen work. The finest roentgenograms seemed to be made on their films but due to their high cost they were not very popular. Production of double-coated films soon declined, perhaps because of manufacturing difficulties.

Prior to World War I, the glass used for photographic plates was secured from Belgium. The war soon curtailed this source and procuring the glass became a very serious problem. The demand for roentgen plates in Army hospitals became almost impossible to satisfy. Even when glass plates were available in large quantities, their bulk and fragility made them exceedingly difficult to transport without breakage. The problem finally made it imperative to provide some other support than glass for the emulsion.

Roentgenography made special demands upon a film support. It required sensitive surfaces of large area. The base upon which the emulsion was to be coated had to support the roentgen-ray emulsion without buckling to any great extent. It also had to be glass-clear. The only thing to be done

was to adopt the cellulose nitrate base used in the manufacture of photographic film. In 1914, a single-coated roentgen film was manufactured with an emulsion of greater sensitivity than that on any roentgen plate made. However, even this film was not ideal; it curled excessively and was therefore very difficult to develop in trays.

The urgency of World War I demanded greater efficiency and speed in roentgen film because of its use with portable roentgen-ray apparatus in the field. This need accelerated the extensive research work then being conducted on a film coated on both sides which made possible the double-screen technic.

Intensifying screens appropriate for the double-coated films were introduced by Carl V. S. Patterson of the Patterson Screen Company[13] in 1916, and much of the credit for continued improvement in screen manufacture must be given to him. It was his work in particular which determined the characteristics of a satisfactory screen: a pure, fine grain, fluorescent chemical; brilliant and uniform fluorescence; and minimal afterglow.

The then current practice of tray development was a deterrent to rapid adoption of these double-coated or "dupli-tized" films. A few laboratories employed deep tanks for processing plates vertically and were able to change over readily when a suitable film hanger became available about 1920. Also, cassettes and other types of film holders to accommodate the new film were placed on the market.

The introduction of film was no easy task. Roentgen workers had so accustomed themselves to glass plates that it took time to convince them that film held forth any advantages over the plates. In 1923, a still faster roentgen film became available. It allowed a radical shortening of exposure time or a lowering of the kilovoltage. The base of this film, like that of its predecessors, consisted of cellulose nitrate.

Cellulose nitrate as a film base had always presented a fire hazard which manufacturers and users recognized. Consequently, other materials of less flammability were sought. By 1906 it appeared that cellulose acetate might provide a practical answer. The actual production of a useful cellulose acetate base, however, required many years of research and development. The contributions of George Eastman and his company to this program are outstanding, although basic inventions and technological improvements were also contributed by other workers and concerns. The program included reduction in brittleness, improved clarity, and greater strength.

Great strides were also made in the recovery processes of by-products of the chemical reactions in cellulose acetate manufacture, which permitted the price to be kept down. World War I gave great impetus to the production of cellulose acetate for other than photographic purposes. This huge consumption made it possible to

Make your records permanent, use
Eastman Dupli-Tized X-Ray Films
"They're Unbreakable"
THERE'S a satisfaction in obtaining perfectly rendered quality when conditions of rare pathological interest are involved. Film negatives not only have unusual diagnostic value, but form permanent records which are readily accessible and conveniently handled and filed.
Ask your dealer for Eastman Dupli-Tized X-Ray Films.
EASTMAN KODAK CO., ROCHESTER, N. Y.

FIG. 10. An early Kodak advertisement (November, 1918) describing "Dupli-Tized X-ray Film"

FIG. 11. Courtesy—Miss Margaret Hoing, Chicago. An unusual historical item showing an early roentgenogram and a "follow-up" made thirty-five years later. The patient was a girl who had been shot by a rifle bullet in 1897. The roentgen examination was made in the laboratory of Wolfram C. Fuchs, Chicago, Illinois. After the examination gold-toned contact prints were made from the *original glass plate*. One was sent to her physician; another was given to the patient and reproduced herewith (left). The original print is in a remarkable state of preservation today. The patient was reexamined in 1932 with modern roentgen film (right) and the bullet may still be seen in its original position.

increase greatly the knowledge regarding the efficient manufacture of cellulose acetate. The results of research finally reached a point where a roentgen film on a safety base of cellulose acetate was produced and placed on the market in 1924.

In 1925 a film was introduced possessing a high degree of contrast and combining a high sensitivity to roentgen rays and to the light from intensifying screens. Further improvements in sensitivity and other characteristics were made in the early 1930's. During this period also a film having a blue-tinted base was introduced by the Du Pont Film Manufacturing Company (1933), and a film for direct roentgen exposure (Non-Screen) was placed on the market by Ansco (1936). Similar products were soon made available by other American and European film manufacturers.

To meet the demand for less and less roentgen exposure to patients, increases in sensitivity have continued to be made, together with improvements in contrast and keeping qualities, and reduction in the inherent fog level.

DENTAL ROENTGEN PLATES AND FILM

The story of dental roentgen plates and film closely parallels the progress of medical plates and film from the earliest days of roentgenography. Special emulsions and

film sizes and a practical packet were problems that had to be met in order to satisfy the needs of the dental profession.

Perhaps the first dental roentgenogram on record was made by Dr. Otto Walkhoff of Braunschweig, Germany, two weeks after the announcement of the discovery of the roentgen rays. This roentgenogram was made of Dr. Walkhoff's own teeth with an exposure of twenty-five minutes. He used an ordinary photographic plate cut to a small size, wrapped in black paper, and covered with rubber-dam.

An Englishman, Frank Harrison, first published an article describing the method of making dental roentgenograms on film in the *Journal of the British Dental Association*, September, 1896. Dr. W. J. Morton of New York was the first in America to make a dental roentgenogram on film prior to April, 1896, using Eastman NC roll film.

The results of these early roentgenograms were rather crude and of little diagnostic value, but they brought to the attention of the dental profession the fact that here was the basis for an invaluable diagnostic adjunct.

The small difference between the density of bone and tooth required that the roentgenogram be of good contrast. Early dental roentgenography was done on photographic plates, films, and bromide papers. However, following the lead of Dr. C. Edmund Kells, Jr., of New Orleans, Louisiana, many preferred to use films.

About 1900, Dr. Weston Price of Cleveland, Ohio, designed a celluloid-base dental film. The celluloid was said to be thick enough to prevent curling but flexible enough to be introduced into the mouth. In an effort to obtain a greater degree of contrast between the tooth structures and the surrounding alveolar process, three emulsion layers were coated on the base instead of one. This product was made and marketed by the Seed Dry Plate Company. The films were cut to size from large sheets and wrapped in black unvulcanized dental rubber.

While glass plates proved satisfactory for the anterior region of the mouth where the curved surfaces did not cause undue distortion, in the posterior region distortion was a problem. Film presented many advantages, particularly its thinness and flexibility which made it easy to place in the mouth. Soon film was used extensively, and Kodak roll film and Seed's double- and triple-emulsion films became favorites.

FIG. 12. The old style hand-wrapped dental film packet above presents quite a contrast to the modern dental film packet appearing below.

The need for a specially wrapped packet containing dental films was an important one. Various wrappers were used, the most successful being black and orange or ruby paper, and black dental sheet rubber then employed as dams. Dr. Kells was probably the first to suggest and use two dental films in a packet so as to have duplicate roentgenograms in case one was lost or sent to a referring physician. Each exposure in those early days required from twenty to ninety seconds.

In 1913, a red, waxed, moistureproof, hand-wrapped paper packet was introduced; in it were two single-coated dental films enclosed in a black wrapper. Various emulsion speeds were employed. These packets were superseded in 1921 by machine-made packets containing single-

coated film. They facilitated placement, were more sanitary, and more comfortable in the patient's mouth.

In 1925, the introduction of dental films coated on both sides with a fine-grain, high-contrast emulsion ("radia-tized"), greatly aided visualization of detail. The first "bite-wing" film packet, designed by Howard R. Raper, D.D.S., to detect interproximal caries, was introduced in 1926.

Like all medical films of that period the early dental films were coated on a base of cellulose nitrate. In 1929, however, the use of cellulose acetate (safety) base was begun. At about this time, the packet was also changed from black to white.

In 1938, a "rapid processing" dental film was announced. An extremely fast film was introduced in 1941, and further improved in speed in 1955. This fast film permits a reduction in the roentgen dose to the patient, particularly desirable in a complete dental examination. The speed of other dental emulsions has been materially increased also for this reason. Over the years, many styles of packets have been employed but the most efficient seems to be a machine-made packet of moistureproof paper with easy opening features. It is a far cry from the first crudely wrapped photographic plates to the neat, sanitary, comfortable dental packet of today.

ROENTGEN PAPER

The first use of sensitized paper dates back to the days of Röntgen's experimental work, for he mentions it in his early publications. In America, the first roentgenogram on paper was made by Professor A. W. Wright, Sloane Physical Laboratory, Yale University, on January 27, 1896.

The quest for more satisfactory sensitive material than glass plate led many workers to experiment with bromide papers. The first sensitized paper, prepared especially for roentgenographic purposes, was announced in the *Kodak News*, a photographic trade magazine, in December, 1896. The title of the announcement, "*Eastman's X-ray Bromide Paper Takes the Place of Plates in Radiographic Work*," is evidence of the high hopes that periodically were felt for such a recording medium. The *stated* advantages of this paper over the use of plates were as follows: It was non-breakable. It could be bent to conform to the shape of the body and thereby secure better contact. It needed less exposure than plates. Its latitude was greater. It was cheaper and simpler to handle. There was no need of making a negative—then a print. Unlike glass plates, there was no useful limit to their size. The time required to produce a finished roentgenogram consumed not more than five minutes. As each sheet of paper was packed by the company in special envelopes, the trouble of "loading" them was eliminated. In addition, any number of "prints" could be made with one exposure, as it was very "transparent" to roentgen rays.

Unquestionably the fundamental reason for the failure of roentgen paper to find general favor has always been its inability to show detail and contrast as clearly as the glass plate or transparent film.

With the average intensity of illumination used in viewing roentgenograms, the range of brightness which can be rendered by the roentgen *film* is approximately in the ratio 1 to 200 (from lowest to highest). This range can be extended by increasing the illumination; in fact, a small illuminator of high intensity is often used to view unusually dense areas in a roentgenogram, inasmuch as the detail is there and only requires more intense illumination to show it. In this way, it is entirely feasible to increase the range of brightness visible in the roentgenograms to the ratio 1 to 1,000. In the case of *paper*, the maximum range of brightness available is about 1 to 30 regardless of the illumination. In practice this means that the range of densities which can be rendered on paper is much less than that which can be rendered on film.

OTHER APPLICATIONS

Polaroid-Land process. The newest addition[25,36] to the list of commercially available roentgenographic recording media is an adaptation of the Polaroid-Land proc-

AN IMPORTANT RADIOGRAPHIC DISCOVERY.

EASTMAN'S

...X=RAY PAPER

ENTIRELY SUPERSEDES DRY PLATES WITH THEIR ATTENDANT DRAWBACKS.

Of Unparalleled Advantage in Surgical Diagnosis by means of the Röntgen Rays.

Being NON-BREAKABLE, the patient can lie down upon it without injury to himself or the paper.
When Distorted Limbs or Curved Parts of the Body are to be radiographed, the X-Ray Paper can be bent to form the perfect contact necessary to a sharp picture.
Positives are made direct on the paper; no after-printing necessary.
Unlike Glass Plates, there is no limit as to size.
No Reversal is needed to obtain a correct print. The first results are accurate, both as to right and left, and as to the lights and shadows of the picture.
Bones appear White, Muscles and Flesh form the Half-tones, and the Background is Black.
Eastman's X-Ray Paper is as rapid as the most rapid X-Ray plate on the market, while the latitude of exposure is greater.
One dozen or more prints can be made and finished at one exposure.
The whole process from the commencement of exposure to the attainment of perfect prints need not occupy more than five minutes.
A Dark Room is not essential prior to development, each sheet of Eastman's X-Ray Paper being packed in a special envelope.

Size.	*Price.*
8½ × 6½	4/3 per Packet of 1 doz. sheets.
10 × 8	7/3 " " "
12 × 10	10/6 " " "
15 × 12	18/- " " "

Other sizes in proportion.

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EASTMAN Photographic Materials Co. Ltd.,
115-117 Oxford Street, London, W.
60 Cheapside, London, E.C.

PARIS: 4 Place Vendôme.
BERLIN: Eastman Kodak Gesellschaft, m.b. H., Markgrafen Strasse 91.
ROCHESTER, N.Y., U.S.A.
Eastman Kodak Co.

FIG. 13. The first Kodak advertisement claiming special roentgen ray qualities of an emulsion coated on paper. Published in *Kodak News*, February, 1897.

ess. In the roentgenographic modification, a dry positive roentgenogram on paper is available within about one minute after exposure is complete. This process has found some application where portability or high processing speed is important, e.g., in military roentgenography in the field or in operating-room roentgenography.

Photoroentgenography. Photography of the fluoroscopic screen was first attempted in 1897 by J. M. Bleyer[4] in his investigation of thoracic disease. Many workers since that time have developed apparatus and cameras to make photoroentgenography a success. Large scale use of this technique for chest surveys employing 35 mm. photographic film was made in 1938-1939 by M. de Abreu and A. de Paula in Brazil.[9]

About 1938 a photoroentgen unit was developed by Dr. Hollis E. Potter,[32] in which 4×5-inch dupli-tized roentgen film was used. In 1940, this unit was adopted by the U. S. Army for examining the chest of all personnel. A stereoscopic device was soon added and stereophotoroentgenograms were made on 4×10-inch film. Image definition—especially of the margins of many lesions—was not entirely satisfactory when double-coated film was employed. To overcome this problem, 4×5 and 4×10-inch *single-coated*, blue-sensitive film was produced in 1941. When a stationary grid and standardized exposure factors were used,

Fig. 14. Roentgen film has been prepared in many sizes for medical work. The largest film (32 by 72 inches) used was for entire body roentgenography of a woman, aged thirty-three, exhibiting hip pathology. The roentgenogram was made with a one-second exposure, 75 kvp., 150 ma. 12 feet focus-film distance, fast screens, and tissue compensating filtration.

this new film was quite successful.[10,14] Since then, emulsions have steadily been improved to satisfy various photoroentgenographic systems employing 35 or 70 mm. green- and blue-sensitive roll films.

Autoradiography. Autoradiography is the technic of locating and measuring the distribution of radioactive elements by means of photographic registration of these elements. This technique has been used for years in the study of naturally radioactive constituents of minerals such as radium, actinium, and thorium.

Discovery of the phenomenon soon followed that of the roentgen rays. Because of the apparent influence of roentgen rays on fluorescence, Henri Becquerel in 1896 investigated a number of fluorescent substances to determine their action upon a photographic plate protected from visible light.[5] He discovered that uranium ores gave off rays which resulted in the exposure of the photographic plate, even when fluorescence was not apparent. Although he did not recognize them as such, these were autoradiographs, since the images were produced by the self-contained radioactivity of the uranium salts. It was Marie Curie's work that proved the phenomenon to be due to radioactivity.

The first published biological use of autoradiography appeared in 1904, as described by E. S. London.[5] In his experiment, he subjected a frog to radium emanation; when the frog was placed on a photographic plate, an image of it was obtained. Others did experimental work along similar lines:[5] Kotzareff obtained autoradiographs of whole organs of animals injected with radium; Lacassagne experimented with polonium; Lomholt, with radiolead.

As long as the radioactive elements were limited to the few naturally occurring ones, the field of autoradiography was correspondingly restricted and the need for special films had not arisen. However, with the

advent of the cyclotron and the development of the atomic pile, it became possible to produce radioactive isotopes of practically all the elements in considerable abundance. The use of such isotopes in conjunction with the photographic plate has placed an extremely valuable tool in the hands of the medical researcher, chemist, metallurgist, and biologist, whereby chemical elements can be traced in various substances, reactions, and processes peculiar to each of these fields of work. A great variety of special films are being used, including fast roentgen-ray films, nuclear track plates, stripping films, and liquid nuclear track emulsions which are applied to mounted sections.

Roentgen cinematography. Within months after Röntgen's discovery, attention was being given to the study of motion by means of roentgenography. John Macintyre, a Glasgow physician, succeeded in demonstrating the flexion of a frog's leg. He tried both the direct method—exposure of a film, and the indirect method—photography of the fluorescent screen. The latter, however, was unsatisfactory because of the dimness of the screen image. While his results were serial roentgenograms rather than true motion pictures, from that time on the idea of recording movement engaged the attention of experimenters.

In subsequent years[18] the work of Köhler (1907), Eykman (1909), Cole (1910), Levy-Dorn (1912), and Groedel (1913) gave emphasis toward improving the direct method, but the mechanical problems of that day made progress very difficult and slow. At first glass plates were used, until Cole and Groedel, working independently, designed special apparatus in which a wide strip of photographic film was used.

The pressure of World War I put an end to the work for several years, but it was resumed in the 1920's. During the past three decades interest has centered on the indirect method, generally called cinefluorography. Continued improvements in apparatus, screens, lenses, and films have spurred activity by workers throughout the world.

In the earlier attempts at cinefluorography, the faster motion picture films were used. Later on, the development of a special fluoroscopic screen permitted the use of highly orthochromatic films the sensitivity of which responded best to the color of the screen light, and with satisfactory contrast and grain.

With the introduction of fluoroscopic image amplification systems, experimentation with various cine films was begun to determine which were best. This work is still continuing. In the meantime, films primarily designed for other purposes are being successfully used.

CONCLUSION

This narrative of the evolution of roentgen plates and film in medical roentgenography is but a small part of the complete story. The associated development of apparatus, tubes, and screens, the research in the chemistry of processing—all contributed a great deal in shaping the character of the recording medium. All this progress has been possible only through the cumulative efforts of many minds—projects in industrial research the constant aim of which is to advance still more the marvelous growth of roentgenology.

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Anthony's Photographic Bulletin
British Journal of Photography
British Medical Journal
Chicago Medical Record
Electrical Engineer
Journal of the American Medical Association
Journal of the Franklin Institute
Kodak News, The
McClure's Magazine
Photogram, The
Photographic Journal, The
Photographic Times

AN AUTOMATIC CONTROLLED PATTERN CESIUM 137 TELETHERAPY MACHINE*

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DURING the late 1940's, cesium 137 was discovered to be one of the high-yield fission products. By 1950 its radiation characteristics were fairly well known and the possibilities of producing large amounts of a chemically pure separated product were under investigation. In 1951 it was decided to use cesium 137 in an experimental teletherapy machine and to combine this use with a study of rotational methods of applying an external beam of radiation to tumor therapy. A number of models of rotational devices were built and a first report was issued in 1953 describing cesium 137 in detail. During the design and construction stages the machine has undergone considerable modification. It was loaded with a 1,540 curie source of cesium 137 late in 1954, and has been in operation for testing purposes since January, 1955. It is now ready for operation.

The original theoretical calculations of the cesium 137 characteristics were based upon the separation of the fission product as a sulfate because of the greater chemical stability of this salt. Since a higher specific activity would be possible with a salt that had a higher proportion of cesium, the Oak Ridge National Laboratory investigated a number of other salts. The chemical difficulties of the preparation of these salts were overcome and the first large scale production was done using the chloride salt of cesium. The radiation characteristics of the first sources verified the reasonable accuracy of the 1953 theoretical predictions. Table I shows the final results obtained on the first two sources. It is expected that these or equally good results will be maintained in future and in larger scale production.

TABLE I

THE CHARACTERISTICS OF THE FIRST CESIUM 137 SOURCES

	Unit	Pellet No. 1	Pellet No. 2	Combined Sources
Weight	g.	33.07	27.86	60.93
Total curies	c	760.	780.	1540.
Specific activity	c/g.	22.90	27.97	25.27
Diameter	cm.	3.18	3.18	3.18
Height	cm.	1.35	1.28	2.63
Volume	cm^3.	10.74	10.18	20.92
Density	g/cm^3.	3.08	2.74	2.91
Radiation/Volume	c/cm^3.	70.77	76.61	73.61

There are both advantages and disadvantages to the use of the isotope cesium 137 in teletherapy. The most important of these are listed in Table II.

Through its short-lived barium daughter isotope, cesium 137 gives off a monoergic 0.661 mev. gamma ray. It also yields, through its daughter, X rays following conversion that are mainly *K* radiation from 32 to 37 kev., but these are absorbed in the source and its capsule. There is some degraded radiation as would be expected from any source that is confined in a high *Z* housing, but the energy in a beam from cesium 137 is roughly equivalent to the average from a one million volt roentgen-ray generator or from a radium pack. Therefore, cesium 137 has all of the skin sparing and depth dose advantages of supervoltage radiation.

An additional advantage is apparent in the fact that although the attenuation in the low *Z* materials of the body ($e^{\mu} = 2.5 \times 10^{-25}$) is only 30 per cent greater than for

* From the Medical Division, Oak Ridge Institute of Nuclear Studies, under contract with the U. S. Atomic Energy Commission, Oak Ridge, Tennessee. Presented at the Fifth-sixth Annual Meeting, American Roentgen Society, Chicago, Illinois, September 20–23, 1955.

TABLE II

ADVANTAGES AND DISADVANTAGES OF CESIUM 137 IN TELETHERAPY

Advantages	Disadvantages
1. Supervoltage (0.661 mev.)	1. Low specific activity
2. Differential attenuation in high and low z materials	2. Low gamma intensity
3. Long half life	3. Chemical preparation of a powdered salt
4. Large scale production	4. Not available until 1957
5. Waste product of all reactors	

Co^{60} ($e^{\mu} = 1.9 \times 10^{-25}$), the attenuation in the high Z materials of housing and protective materials ($e^{\mu} = 4.2 \times 10^{-25}$) is 80 per cent greater than for Co^{60} ($e^{\mu} = 2.3 \times 10^{-25}$). Thus, although the penetration in the body is not much reduced, the problem of shielding the beam is notably reduced with cesium 137.

The long half life of thirty-five years gives cesium 137 an obvious advantage over other isotopes but this is accompanied by a number of disadvantages that must be accounted for in the design of equipment. The I_{γ} value of cesium 137 is about 0.4 rhm per curie as compared with 0.8 for radium and 1.3 for cobalt 60. Thus, in terms of curiage, it will take about twice as many curies of cesium 137 to equal a radium source and about three to four times as much to equal a cobalt 60 source. For this reason, even though the specific activity of cesium 137 seems as high as most cobalt 60 sources, the curiage of cesium sources must be measured in terms of many kilocuries and the sources themselves will have larger dimensions.

Among the greatest of the advantages of cesium 137 is the fact that, as a fission product, it is being produced in every nuclear reactor no matter what the purpose of the reactor. With a rapidly expanding program of reactor construction for power, sterilization, weapons, experiment, training, and locomotion, an enormous production of cesium 137 is now occurring. This isotope is a true waste product since the fission products must be removed from the fuel of a reactor periodically in order to maintain efficiency. The first step in purifying the reactor fuel is also the first step in obtaining purified cesium. Also, other fission wastes have a potential economic value as great as that of cesium 137 and the total cost of purification need not be borne by the users of cesium 137. Further, teletherapy is not the only use for cesium 137 and in the future may well be one of the very minor uses. Fission product technology is still in its infancy. The first pilot plant for large scale production is now nearing completion and the biggest disadvantage of cesium 137—unavailability—is expected to be overcome by 1957.

Most of the hectocurie cobalt 60 machines now in use are capable of receiving cesium 137 sources for straightforward routine therapy. No special problems are foreseen in the use of cesium 137 beyond minor adjustments in dosimetry. Therefore, the machine that was built to accept the first multikilocurie source of cesium 137

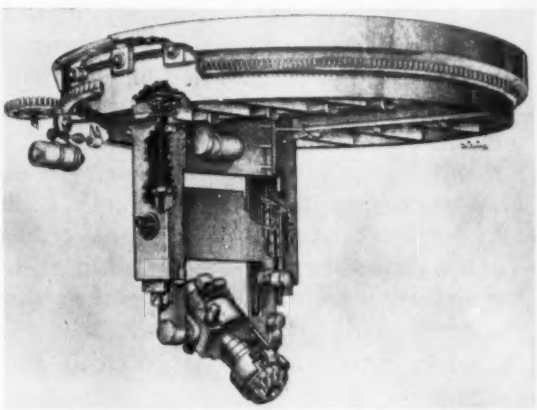

FIG. 1. Cutaway drawing of the automatic controlled pattern cesium 137 teletherapy machine. (Courtesy of W. F. and John Barnes Company.)

was designed for special purposes (Fig. 1). It was not intended for use as a practical therapy device. Rather, it was designed to investigate the comparative dosimetry of more complex procedures. For this reason, an attempt was made to design a machine that could accomplish any predetermined moving field pattern. It was designed to rotate the machine, the patient, or both, simultaneously without regard to the practicality of either. The ideal design would allow the therapist to construct within the body any shape or volume of radiation intensity. Because some patterns of rotation are too complex for manual positioning, an automatic computer mechanism was included. Because of the irregularities of the shape of the body, an automatic wedge filtration was built in to allow for a predetermined distortion of the isodose curves. Because of the size of the source, an iris diaphragm and a telescoping collimator were included. Because of the complexities of the moving field patterns allowed by the machinery, an automatic dose-time setting and computer were included.

The machine is constructed so that the beam of radiation can be pointed in any direction on simple cylindrical orthogonal coordinates (Fig. 2). However, when set for "automatic pattern," the cesium 137 source moves over a spherical locus with the beam directed through a central target point fixed in space. The radius of the spherical locus is adjustable to permit variation in source to focal point distance (SFD) from 50 cm. to 90 cm. Thus, the beam can approach a recumbent or sitting patient from any angle except from directly below.

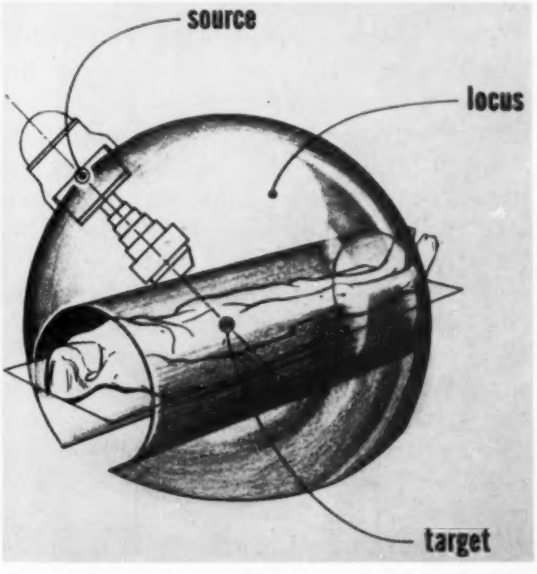

Fig. 2. The machine can perform all possible motions in a sphere, around the patient, of a radius from 50 to 90 cm. source-tumor-distance. (Courtesy of W. F. and John Barnes Company.)

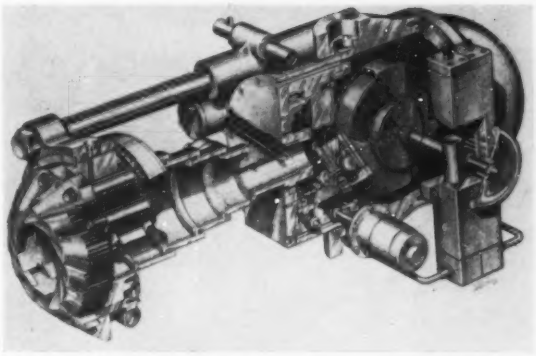

Fig. 3. Cross sectional cutaway drawing of the experimental teletherapy head. (Courtesy of W. F. and John Barnes Company.)

The source housing consists of the now familiar internal rotating wheel shutter inside a steel-clad lead primary shield (Fig. 3). It is suspended by a telescoping fork that allows both tilt to any angle and vertical motion. The fork is on a circular ceiling suspension with a horizontal track and a circular azimuth track. Thus, the structure allows four basic motions: head tilt, vertical, horizontal across the ceiling ring, and azimuth motion around the vertical axis. Any pattern of motion desired may be had by coordinating these basic motions.

When the machine is set on automatic control the various motions are coordinated by a series of cams that transmit their instructions to cam followers through a scotch-yoke coupling to the motors (Fig. 4). Four D.C. motors are position-served to ten-turn potentiometers. The vertical and horizontal components of travel are linked

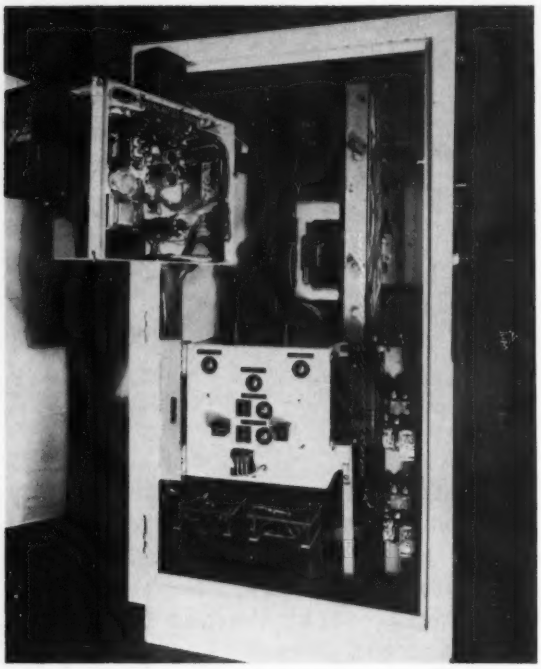

FIG. 4. The speed and direction of the motors activating each element of motion are controlled by an analog computer.

to a tilt motion that keeps the beam on the target point. As the tilt angle is changed the vertical position of the head changes with the cosine of the angle of tilt and the horizontal position changes with the sine of the angle. The source thus follows an arc of constant radius and the beam stops on the target. An adjustment of the scotch yoke changes the radius of the spherical surface over which the source is allowed to travel. The azimuth motor is controlled by a separate cam system.

In complex moving field patterns the shape of the body can cause great variation in the depth of the tumor. Therefore, a wedge filter is necessary to distort the isodose curves, to produce either a homogeneous or a variable dosimetry within the body. This wedge filter must be able to enter the beam from any direction and to extend to any depth. Its action must be coordinated with the motion of the source. Thus, there are two additional cams on the automatic computer: one to control wedge depth, and one to control wedge azimuth.

If it is desired to stop or start the radiation at any point in a controlled pattern, this is accomplished with a dual set of compressed air pistons. These power-activate the shutter to both "on" and "off." An additional spring loading brings the source back to "off" in case of power failure. The dual power-activated shutter is used to minimize the already negligible error due to the rotation of the shutter wheel. The number of "on," "off" settings is currently placed at four variable positions in one cycle but is limited only by the physical size of the cam-dogs that activate the shutter and by the fraction of a second it takes to turn the shutter wheel.

A therapy table is an integral part of the mechanism. It is a highly modified surgical table with all varieties of tilt motions, vertical and horizontal motions, and a rotational motion that is coordinated with the central control console. All of the manifold positioning devices common to the surgical operating room are attachments to the table. Four cross hairs of light are affixed to the walls and focus at the point in space representing the target. A light localizer inside the treatment head accurately outlines the beam of radiation.

There are three separate sets of controls. The first is a setup control panel in the treatment room. This allows for only a manual setting of the machinery into any desired positon. The beam cannot be turned on from this station and it is available primarily for simple single portal therapy and routine isodose studies. The second control is a central control console (Fig. 5). It duplicates in the control room all the machine positioning devices of the setup panel. The third set of controls is on the automatic computer console (Fig. 6). These controls act primarily to indicate the exact position of the machine when it is on automatic cycle.

The central control console is the main station and has a large variety of signal lights that inform the operator of the status of each mechanically functioning unit. Since treatment time will depend upon the

dose desired and the length of a moving field pattern, a simple rotary slide rule is attached; it automatically sets the motors to a coordinated speed to deliver the desired dose in the proper time and space.

With such a complex mechanism there is a possibility of human error in making the settings of dials. Therefore, on the control console, there is a set of dials that automatically records the total time on and the dose delivered to the focal point. This device can be set to record either the dose to the focal point in air or to a precalculated point in tissue depth. It is adjustable to accommodate the decay of the isotope. Although there is little possibility of error in the mechanism, if a patient should sit up or move during a treatment cycle he might come in contact with eight tons of steel moving with the force of a few 24-horsepower motors. Therefore, there are touch-guards on the projecting parts that, when actuated by a few ounces of pressure, will stop all motors, cut off the beam, and freeze all motion in a fraction of a second.

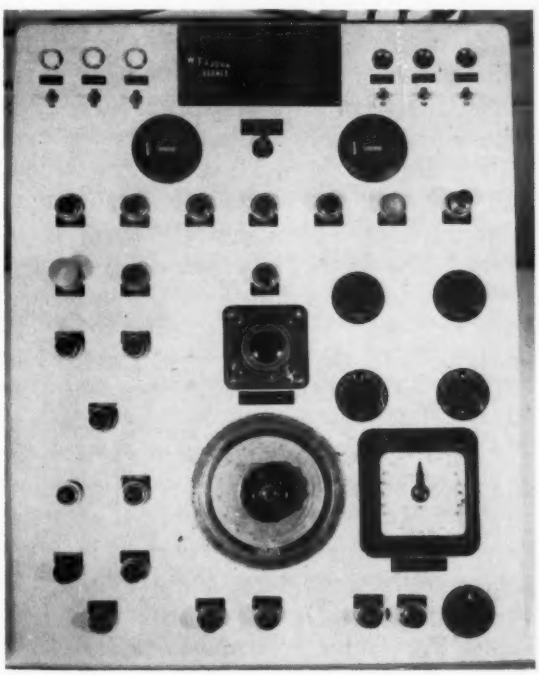

Fig. 5. The central control console is the main operating station for stationary therapy or automatic movement. It has a variety of signal lights that inform the operator of the status of each mechanically functioning unit.

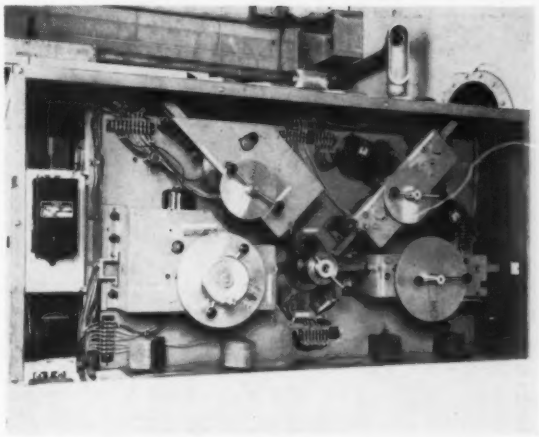

Fig. 6. Cam followers, on the automatic computer console, determine each element of motion.

All of the motors receive their instructions from very sensitive servo-amplifiers. Each of these has two stages of magnetic amplification followed by a pair of thyratron tubes that supply current to each motor. The thyratrons are connected back to back in a half-wave controlled rectifier circuit. When the unbalance voltage is of one polarity, the magnetic amplifier causes one thyratron to conduct and drive the motor to reduce the unbalance. When the unbalance is overshot, the polarity changes, causing conduction of the other thyratron, and the motor is reversed. A special prediction circuit damps out all but a minor fraction of the tendency to overshoot the balanced state. A malfunction of any unit automatically shuts off and freezes all machinery.

Thus, there is great accuracy in the control system. The speed of the machine is variable so that a complete cycle can be performed in as fast as five minutes to as slow as twenty minutes. The focal point is maintained within less than 1 cm. of deflection with proper cam design. When a very sharp angle is put on a cam so that one component of motion is forced to travel excessively fast while the other components are at slow constant speed, there is a possibility of momentary lag in the fast

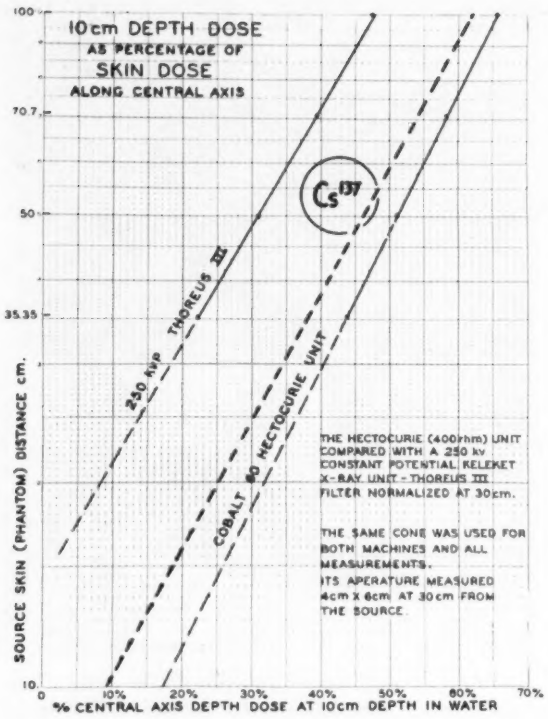

FIG. 7. Comparison of relative depth dose with three sources of radiation.

component and the target point will be momentarily undershot. This never happens in the usual patterns of vertical or horizontal arc moving fields but may happen when unusual "figure 8" or "narrow saddleshape" or other improbable patterns are attempted.

Each of the controlled patterns of motion is generated by specially prepared cams driven at the proper speed by the cam shaft motor. A relatively few sets of cams can describe many varieties of conical, pendulum, or rotational therapy. To assist in the design of special cams for highly unusual patterns of motion and to help visualize the total pattern in relation to the body landmarks, a desk-sized model has been prepared. The desk-model cam plotter is calibrated to the same scale readings as the machine; by manually maneuvering the model, a near-infinite variety of travel paths and wedge filters can be constructed.

The workings of the machinery can be illustrated by tracing the events during one commonly accepted pattern of moving field therapy. Consider the procedure involved in performing a single 45° conical arc rotation with the beam shut off during a 15° gap in the conical pattern. The proper cams are inserted into the computer and the cam-dogs are positioned to shut off and turn on the beam during the 15° arc desired. The dose required and an "on" cycle of 345° are set onto the slide rule. This automatically sets the motors to the correct speed of rotation. The machine has already been calibrated to record central tumor dose. With the aid of the cross hairs of light and the light localizer, the patient is then positioned on the table with the center of his tumor fixed at the focal point. A push on the start button begins the treatment.

The machine always starts from a fixed rest position. When the pattern is started, the first few degrees of cam rotation move the machine into position to start the conical arc of rotation. Meanwhile the wedge filters move into position to start the correction for the different depths of tumor at the edges of the beam. When the machine arrives at the starting point of a 45° angle, the beam automatically cuts "on." The circular motion then starts and the source travels from 0° azimuth to 360° azimuth while the wedge filter continually adapts itself to follow the cylindrical shape of the body. At the 15° gap in the treatment cycle the beam is automatically cut "off" and "on." At the end of the cycle the beam shuts off and the machine returns to rest position. The accuracy of repeating the pattern the next day will depend upon the accuracy of positioning the patient since the machine will duplicate its action identically.

Another simple way of performing this same pattern would be to manually position the machine and to rotate the treatment table. For faster treatment, or slower, a combination of the two methods could be used, or the skin focus distance could be shortened or lengthened. The axis of the conical arc could be tilted to expose a different segment of overlying tissue. Any of

a variety of modifications could be arranged for by different combinations of the various settings. Although the procedure may sound complex in description, it is no more difficult than any routine single portal treatment.

The machine will be available for the treatment of patients under the direction of the ORINS Teletherapy Evaluation Program, but its primary purpose is not routine therapy. The machine was designed to study dosimetry in various patterns of rotation. Its time is programed to study first the simple isodose curves of cesium 137 (Fig. 7). The results of the first studies show the expected comparison of 10 cm. depth dose of Cs^{137}, Co^{60}, and 250 kvp. beams in a water phantom. Iridium, europium, cerium, and other sources are available for comparative studies.

One of the more important items on the program is the determination of integral dose as a function of rotational pattern and energy. Preliminary work with the cobalt 60 hectocurie unit by Drs. Hayes of Oak Ridge, Tennessee and Lofstrom of Wayne University, Detroit, Michigan, indicates the ultimate simplicity of the problems of integral dose during rotation. There have, however, already been sufficient surprises in what was once thought to be routine test measurements to indicate that perhaps the highest energy is not always the ideal energy (Fig. 8). Perhaps the simple rotational patterns available with a moving chair are not always ideal. The literature of radiation therapy is full of therapeutic decisions that actually were forced by the limitations of a piece of machinery. The purpose of this exceedingly complex device is, thus, to study therapeutic procedures unhampered by the bias of mechanical restrictions.

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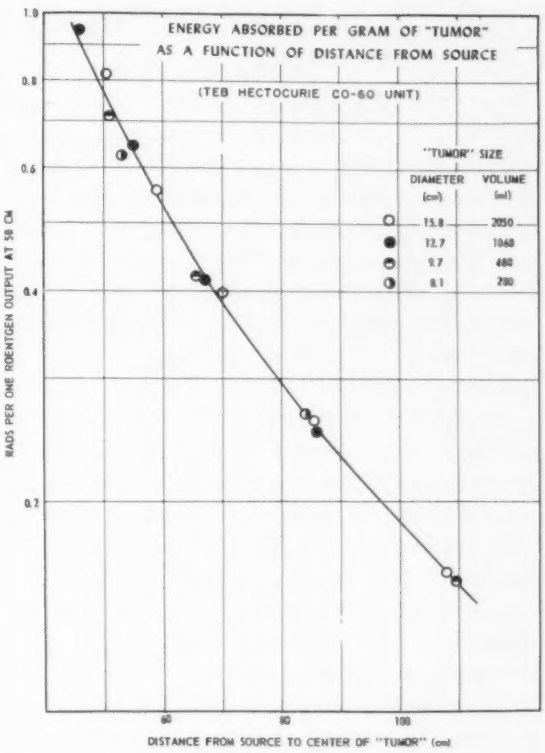

Fig. 8. Energy absorbed per gram of "tumor" as a function of distance from the source. The "tumor" is centered in the "torso"; "torso" size constant.

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PROGRESS IN INDIRECT CINEROENTGENOGRAPHY

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FOR over fifty years the idea of making motion pictures of the fluorescent screen image has intrigued radiologists. There were many reasons for the radiologists' initial interest in cineroentgenography. It was quite apparent that a series of single films though obtained in rapid sequence, could not provide as much information as a motion study. Cineroentgenography would (1) serve as a permanent record of the movement of the fluorescent screen image which could be used for future reference and study; (2) enable the radiologists to study in slow motion a rapidly occurring event; and (3) make it possible to avoid the difficulties encountered with rapid film changing equipment.

In order to satisfy the need for cineroentgenography, the early investigator developed his own equipment. This paper records the progress in equipment construction from the early days of the roentgen ray to the present time and presents some problems for future equipment development.

Russell Reynolds[18] in 1938 reviewed the literature on direct and indirect cineroentgenography and defined these terms as follows:

"Direct cineradiography consists in using a band of film each exposure of which will be of sufficient size to contain a natural size image of the parts to be roentgenographed and . . . in exposing this film close to the patient's body."

"Indirect cineradiography consists in photographing, with an ordinary cinematographic apparatus, the image on the fluorescent screen."

Scott[27] in the 1950 Carman Lecture presented an excellent review of the use of direct cineroentgenography.

Improvements which have been introduced in the indirect cineroentgenographic equipment during a twenty-seven year period are presented first.

EQUIPMENT DEVELOPMENT

The first major publication on indirect cineroentgenography, according to Lawrence Reynolds and coworkers,[17] was made by Russell Reynolds[19] in 1928, who used a Coolidge tube which operated at 90 kv. and 40 ma., a movie camera equipped with an f1.9 Dallmeyer lens, and Kodak ultrarapid film. A one-quarter horsepower motor drove a large contact wheel which synchronized the roentgen-ray generator and camera shutter so that the roentgen tube was "on" only when the camera shutter was open. Lead glass was placed in front of the camera to decrease the amount of roentgen rays to the unexposed movie film.

Seven years later Russell Reynolds[20] described the use of a 16 mm. camera equipped with a Zeiss fo.85 lens and driven by a synchronous motor. This is the first reported use of this lens for cineroentgenography. Stewart and associates[28] in 1937 presented their experience using a 16 mm. camera equipped with a Zeiss Biotor fo.85 lens with which they were able to photograph a 30 by 50 cm. field. Very few reports of indirect cineroentgenographic work appeared in the literature during the ten year period, 1937 to 1948.

Watson and Weinberg[30] published in 1948 a description of a 35 mm. camera unit equipped with a Zeiss R-Biotor fo.85 lens with which they photographed the image on a Patterson E2 screen, $14\frac{1}{2}$ by $14\frac{1}{2}$ inches in size. A variable speed motor permitted the use of camera speeds in the range of 6 frames per second to 32 frames per second. An electrical system was required for gradual starting (over a several second interval) of the camera shutter because a relatively heavy lead shutter was used. The problem of getting the camera to the required speed, e.g., 60 frames per second in several seconds, was discussed by Ramsey[15] in 1949. In this same article he described a method of checking the synchronization

of camera shutter and roentgen tube "on" period by using an oscilloscope. The synchronous motor shaft was "slipped" until the oscilloscope indicated that the camera shutter and roentgen tube were synchronized. Ramsey also presented figures on the amount of film used for a 3 second run at 60 frames per second. He found that 4 feet of film a second passed through the camera at 60 frames per second. Before the camera had reached full speed, 8 feet of film had been used, and 4 feet of film were used as the camera coasted to a stop at the end of the examination. Therefore, 50 per cent of the approximately 24 feet of film had been wasted. This problem of inefficient use of film is still a disadvantage of cineroentgenography.

Janker[9] in 1950 introduced two features in his cineroentgenographic equipment. A 35 mm. camera was mounted inside a lead-lined table in a light-tight compartment and the fluoroscopic image was reflected from a 45 degree mirror into the camera lens. With this arrangement, the heavy lead camera shutter was not needed. The shutter was made so that it was closed 90 degrees and was open 270 degrees, while the roentgen tube was energized only three quarters of the time that the shutter was open to avoid the effect of screen lag.

Lawrence Reynolds and coworkers[17] and Rushmer, Bark and Hendron[21] produced further refinements in the cineroentgenographic equipment to be used for teaching and for clinical cinefluorography. These refinements included a shutterless camera and a focusing mechanism for depth of field by Reynolds and the construction of the cinefluorographic equipment in a fluoroscopic table by Rushmer.

Morgan and Sturm[14] in 1951 presented a radically different type of cineroentgenographic equipment. An image orthicon was used to scan an ordinary fluoroscopic screen. The image orthicon signal was amplified and transmitted by closed circuit television to several television picture tubes—one of which could be photographed by a movie camera. Morgan and Sturm used approximately twice the number of scanning lines of ordinary television equipment with the result that radiologists who have seen these television pictures have been impressed by the high quality of the image.

For those who suggest that 70 mm. film should be used for cineroentgenography, the report of Watson, Weinberg and Ramsay[31] is cited. They found the detail gain of 70 mm. film versus 35 mm. film was in the range of 1.44 to 2 depending on the field size of the fluorescent screen. The resolving power for this size film averaged over the entire field was 15 per cent less than at the center. The film bulged about 10 per cent in the center; therefore, a compressed air jet was required to hold the film flat. The engineering difficulties encountered seemed to outweigh greatly any benefit from gain in detail.

Miller and coworkers[11] have used a Superdynamax tube operated to 120 kv. 200 ma., to obtain as much light as possible from a Patterson E2 10 by 12 inch fluorescent screen. To gather the optimum light from the screen, an Eastman Fluoro Ektar fo.75 lens was mounted on a 35 mm. camera. The fluorescent screen was placed above a 45 degree mirror and mounted at one end of a long aluminum box which was light-tight when closed (Fig. 1). The 35 mm. camera unit was mounted inside the box at the end opposite the mirror.

About two years ago, the fluoroscopic image intensifier caused renewed interest in cineroentgenography. The ease with which a camera could be attached and the small amount of roentgen rays required, compared with earlier systems, made the image intensifier the obvious favorite for cineroentgenography.

The Philips image intensifier and the associated 16 mm. camera equipment used by us is shown in Figure 1 and 2. Two 45 degree partially silvered mirrors mounted above the image intensifier eyepiece permit the radiologist to observe the image which is being photographed. A small amount of light passes through the second mirror to a

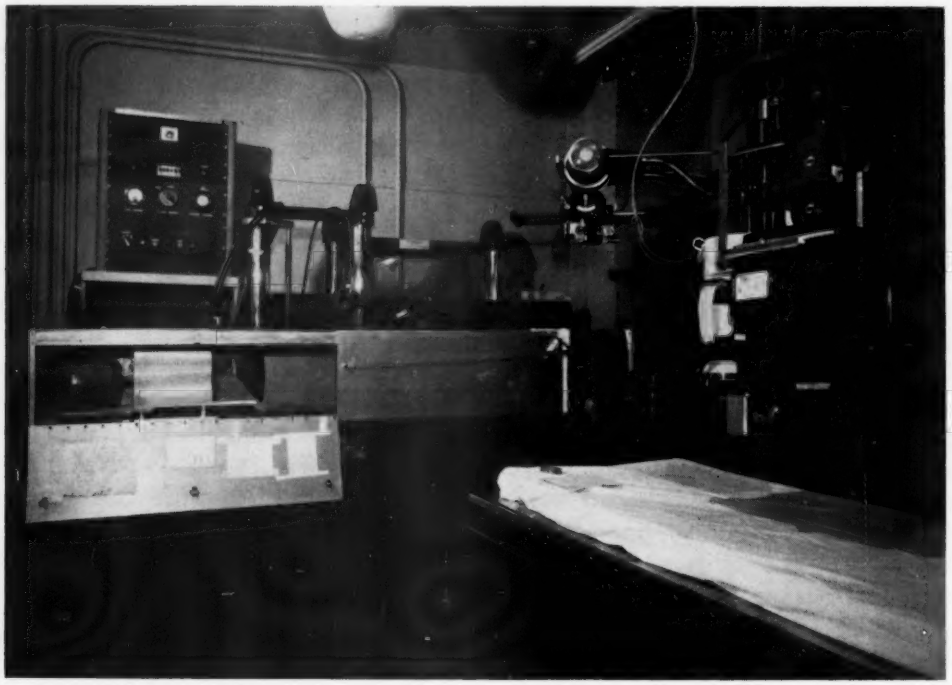

FIG. 1. Indirect cineroentgenographic equipment: 35 mm. camera unit at left. Note dynamotor and camera mounting for f0.75 lens inside the aluminum box. Image intensifier and 16 mm. camera unit at right.

multiplier phototube which acts as a light meter. The phototube output which is read on a 50 microampere meter is kept constant during an examination by varying the roentgen tube current. A film of uniform density is thereby obtained. An interesting feature of this equipment is the electronic control for the camera drive of the 35 mm. and 16 mm. camera units (Fig. 3). A 28 volt airplane dynamotor was attached directly to the camera film drive mechanism. The speed of the dynamotor and the camera was determined by the armature voltage which was varied to select $7\frac{1}{2}$, 15, 30, and 60 frames per second. The dynamotor generator output was connected to an electronic circuit which loaded the generator and synchronized it with the roentgenographic equipment. No phase indicator was required with this system. Other workers[1,4,29] are using the image intensifier for cineroentgenography, and two commercial units with 16 mm. camera attached will soon be available.

Some very interesting work is being done by Rushmer and coworkers[22] and Weinberg[32] with stereocinefluorography. Two roentgen-ray tubes are used to expose the films and polarizing light filters are used on the two cameras. When the film is viewed with polarized glasses, the three dimensional effect is striking.

USE OF CINEROENTGENOGRAPHY

During a recent symposium on cineroentgenography* the equipment status for indirect cineroentgenography was discussed and uses for the equipment were presented. (Some uses and limitations had been reported previously by Miller.[12]) The three fields of activity defined for cineroentgenography were: (1) research, (2) teaching, and (3) patient service. Morgan felt that these three categories could be weighted in importance as follows: research, 40 per cent; teaching, 40 per cent; patient service, 20 per cent.

Westermark,[33] Holmgren,[8] and Rushmer and coworkers[23,24] have presented evidence

* Members of the panel were Drs. Russell H. Morgan, Robert F. Rushmer, George H. Ramsey, H. Stephen Weens, and E. R. Miller, moderator.

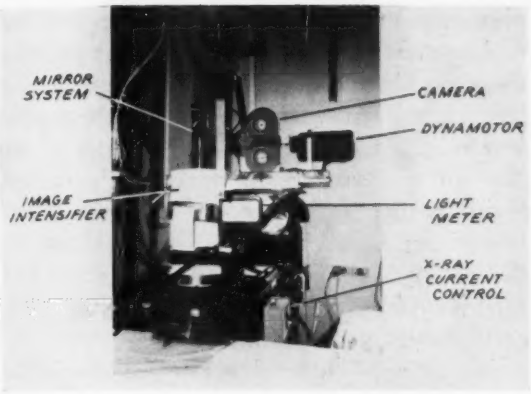

Fig. 2. Image intensifier and 16 mm. camera unit mounted on fluoroscopic screen support.

that cineroentgenography is a useful research tool. Lawrence Reynolds and coworkers[17] have demonstrated that it is an important teaching device.

Cineroentgenography may be helpful as a patient service in the following types of examinations: (1) angiocardiography,[10,25] (2) cerebral angiography,[5,7] (3) swallowing,[16,26] (4) gastrointestinal series, (5) urination studies[6] (6) joint movement, and (7) diaphragm movement.

SKIN DOSE

A review of the literature on this subject indicated that the majority of the authors[9,11,21,30] considered 20 r to 25 r on the skin to be the maximum exposure for a cineroentgenographic examination. We believe that it is necessary to calculate carefully the skin dose for each examination because the desire to obtain a film of adequate density may lead to excess patient exposure. A slide rule has been developed[13] for rapid calculation of skin dose from the roentgen-ray operating factors of kilovoltage, milliamperage, target-skin distance, filter, and frames per second.

Use of the image intensifier has made it possible to reduce the skin dose. Roentgen-ray operating factors often used are 70 kv. to 90 kv. and 1 to 5 milliamperes. However, the decreased quantity of roentgen rays used by a radiologist with an image intensi-

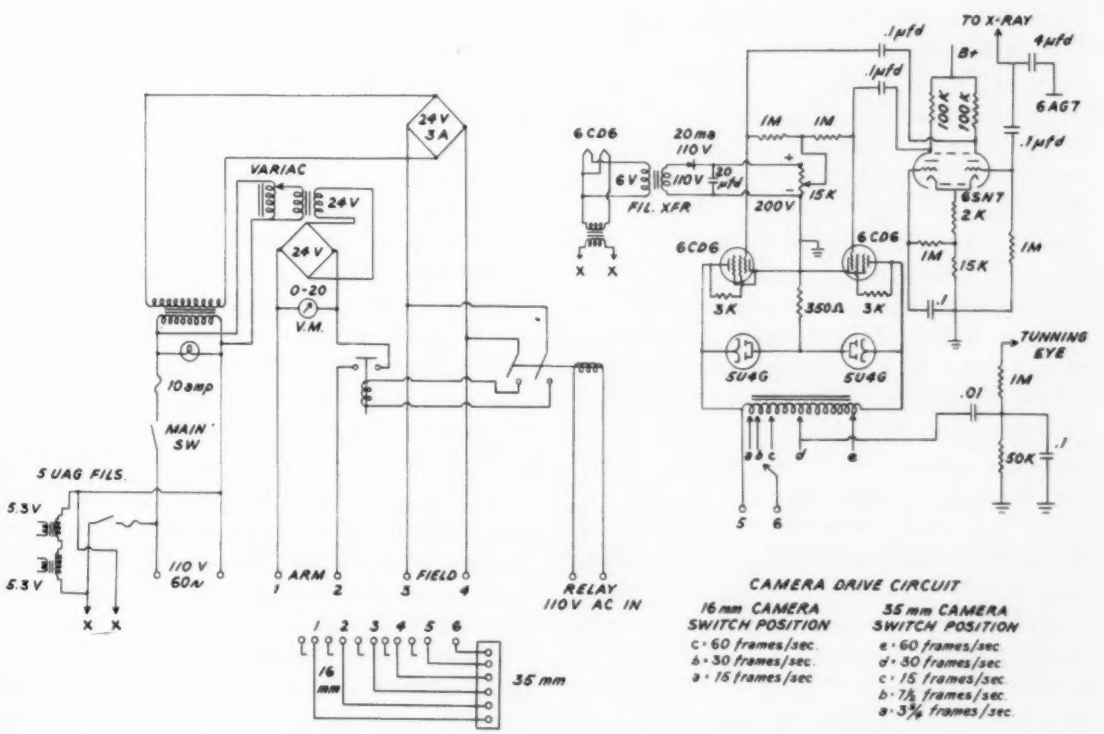

Fig. 3. Electronic circuit for camera drive and synchronization unit. Dynamotor drive circuit shown at the left—synchronization circuit shown at the right.

fier should not lull him into a false sense of security, for roentgen rays are still penetrating the patient.

The television system of image brightening requires operating factors for the fluoroscope of 70–100 kv. and 5 ma. tube current.[14] Consequently, the quantity of radiation received by the patient with this system is approximately the same as the amount received during conventional fluoroscopy.

DISCUSSION

In a recent article on the scintillation limit in fluoroscopy, Coltman[3] stated, "Electron fluoroscopy will be capable of resolving powers well in excess of those accepted as satisfactory in present day screen film radiography." The implication of this statement is important to the field of cineroentgenography for it means that the resolving power of the movie film will not be limited by the intensifying device. This statement should encourage further development of cineroentgenographic equipment. There are five main areas where investigation should continue:

(1) The fluorescent screen: More efficient phosphor should be developed. Radiologists recognize this fact, and it is of interest that physicists who are working in the field of high energy radiation and astronomers also are interested in more efficient fluorescent screens.

(2) Movie film: Research should continue on movie film characteristics. A more efficient fast film will allow the number of milliroentgens per frame to be decreased—for optimum film density—and thus the patient's exposure will be decreased during the cineroentgenographic examination.

(3) Television intensification system: At the present time only the image orthicon type of television pickup tube has enough sensitivity to scan the fluoroscopic screen directly. The amount of light from the fluoroscopic screen during a gastrointestinal series or a barium enema[2] is only slightly above the sensitivity limit of the image orthicon. The vidicon, a less complex and less expensive type of television pickup tube, is available, but at the present time the vidicon does not have the required light sensitivity to scan the fluoroscopic screen directly. Tube manufacturers are now in the process of making the sensitivity of the vidicon equal to that of the image orthicon. When such a vidicon is perfected, a compact and reasonably priced television intensification unit for cineroentgenography can be constructed.

(4) Image intensifier: Commercially available image intensifier units are limited to a 5 inch diameter screen and an intensification factor of 1,000 to 2,000. The most severe limitation is the field diameter and the greatest need at the present time is an intensifier with a 12 inch diameter field.[12] Of course, a more efficient phosphor would increase the intensification factor, but improvement in the electron amplification will eventually give the greater degree of intensification.

The available image intensifiers give enough increase in light level so that the sensitivity level of the vidicon tube is reached for certain types of examinations. An image amplifier and a vidicon pickup tube with accompanying amplifier, control equipment, television viewing screen, and movie camera comprise a satisfactory cineroentgenographic unit for such examinations as swallowing; joint motion of fingers, wrist, elbow, and shoulder; diaphragm motion; and angiocardiography in infants.

(5) Roentgen-ray tube development: It is difficult to obtain consistent roentgen exposures of very short duration at high kilovoltage and rapid repetition rate.

The triode type of roentgen-ray tube may be a solution to the problem of producing millisecond roentgen exposures in the 120 kv. range. Anode heat dissipation must receive special attention in this tube, for the short roentgen-ray pulses require a rugged target. In addition, a small focal spot (1 mm. or less) should be used. As an answer to heat and small focal spot problem, an anode that rotates at 36,000 or more revolutions per minute has been sug-

gested. Bearing mounts for such an anode offer many difficulties. A roentgen exposure of very short duration can be used for cineroentgenographic circulatory system studies to "stop" the motion of blood flow and heart valves.

CONCLUSION

From our three years of experience with cineroentgenography it is apparent that the present systems have serious limitations which result from (1) the problem of skin dose with the high kilovoltage unit and (2) the problem of the small field size available with the image intensifier unit. However, in spite of these limitations and the added factors of expense, time, and effort required, we still feel that cineroentgenography is worth while for certain types of examinations. We think that indirect cineroentgenography will be helpful to those investigators interested in physiological studies, e.g., blood flow and heart valve movement, urinary tract function, and esophagus movement. Cineroentgenography will be an aid also to those interested in certain clinical cardiovascular problems, e.g., some types of congenital heart disease, peripheral vascular problems, and circulation in tumors.

In addition, we believe that cineroentgenographic study of swallowing improves the ability to interpret the phase of swallowing as demonstrated by barium swallow on plain films of the neck. Similarly, it enables the radiologist to obtain more information from the fluoroscopic examination of swallowing because he knows what to look for and when to look.

SUMMARY

Cineroentgenographic equipment development during a three decade period is presented.

Improvements in electronic techniques and fast movie film have contributed to the recent rapid progress in indirect cineroentgenography.

A skin dose of 20 r to 25 r per examination is considered to be the maximum amount that should be permitted.

Cineroentgenography is an aid in research, teaching, and patient service. Some developments which will increase the usefulness of indirect cineroentgenography are suggested.

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CINEFLUOROGRAPHY: TECHNICAL REFINEMENTS*

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THE FILM ANALYZER

IF MAXIMUM information is to be extracted from roentgen-ray motion studies, the films should be viewed both in motion and as stills. In some respects the former method of inspection could be called qualitative, the latter quantitative. At any rate the two methods supplement each other and are at their best when used in conjunction. Thus, no matter how carefully the individual frames are examined, additional details are nearly always revealed when the film is viewed in motion. These details cannot possibly be located on individual frames except by constant references to the moving film.

The projector for this work should have the flexibility of a film editing machine, but with better registration and detail and more light intensity. What is wanted is to be able to run the film forward or backward at slow speeds without flicker, and to be able to change quickly from continuous to single frame operation and back again. To meet these requirements a special 16 mm. projector, illustrated in Figure. 1, has been developed with the help of engineers of the Eastman Kodak Company.[7] It is actually a modification of Kodak Analyst projector, a machine much used by athletic coaches for postmortems on football games and similar contests.

The standard Analyst has a number of features not found in other 16 mm. projectors, including an independent motor for the cooling fan and heat absorbing glasses and coatings in the condenser system. To these have been added: A five blade shutter with matching pull-down cam to reduce flicker at slow projection speeds, a remote control, single framing device, capable of moving the film one frame at a time in either direction, an extra blower for cooling the side of the film away from the lamp, and an automatic diaphragm which keeps screen illumination constant whether the projector is running or standing still. With the modified Analyst, reasonably flicker-free projection is possible at speeds as low as 6 frames per second, while the change from continuous to single frame operation can be made instantly without special adjustment of focus or illumination. These time saving features encourage a much closer reading of roentgen-ray motion studies than has been practicable hitherto.

COMBINATION OF CINEFLUOROGRAPHY AND CONVENTIONAL CINEMATOGRAPHY

It may sometimes be useful in teaching films to have the subject appear partly transparent (penetrated by roentgen rays) and partly solid. This is done by replacing the fluorescent screen of the cinefluorographic unit with a pane of glass or lucite and by attaching to the glass a smaller screen, covering only a portion of the camera field. The position and shape of the screen will depend on the effect aimed at. For example, if we want to show the respiratory movements of the diaphragm and lung bases roentgenologically and those of the upper thorax and clavicles by conventional cinematography, the screen need occupy only the lower half or third of the field.

Lighting the subject from the sides is not too difficult if the near point of the subject is positioned 1 or 2 inches from the screen plane. The surface lighting should be soft and subdued so as to match the fluorescent image. Because the camera lens is focused on the fluorescent image of the subject rather than on the subject itself, there will always be some unsharpness of the surface-lighted part of the picture. There is also a difference of magnification

* From the Department of Radiology, University of Rochester School of Medicine and Dentistry. This project was supported in part by a research grant from the National Heart Institute of the National Institutes of Health, United States Public Health Service.

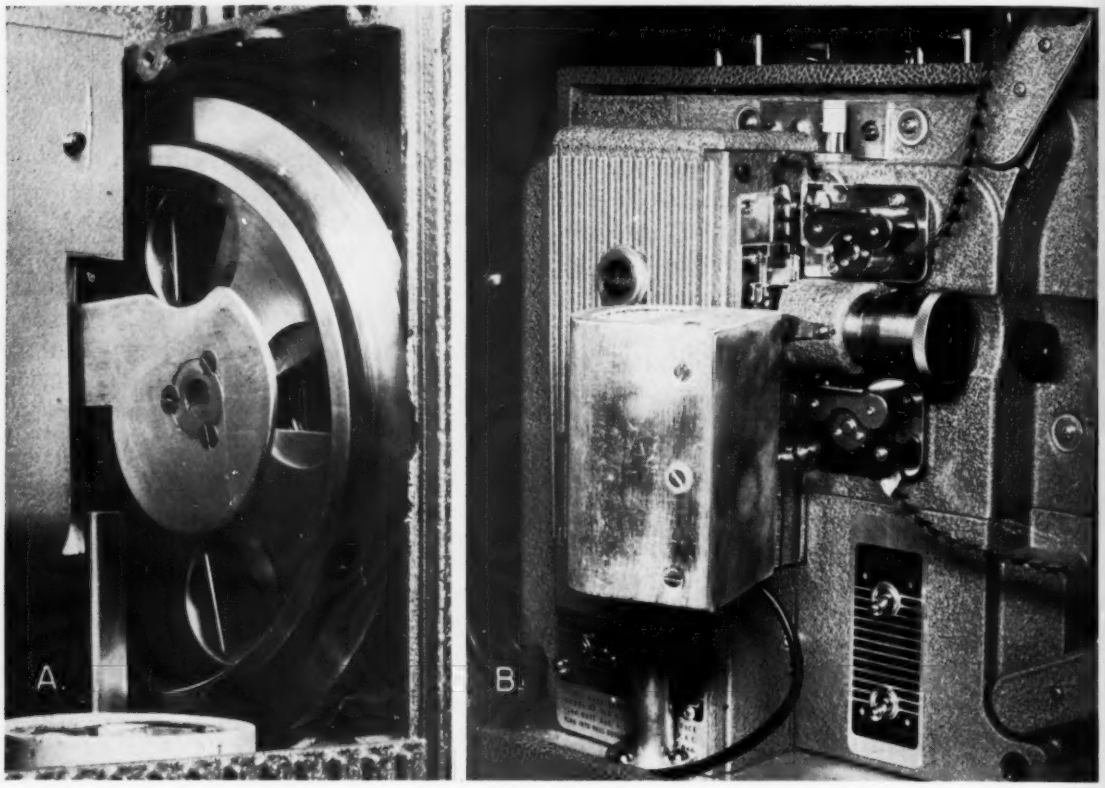

FIG. 1. Kodak Analyst projector after modification. (*A*) Rear view of five blade shutter and automatic diaphragm. Lamp and lamp house have been removed. (*B*) Side view showing extra blower for cooling front of film.

in the two parts of the picture due to the opposition between natural and roentgen-ray perspective. The edges never quite match, and the discrepancy makes the spectator vaguely uncomfortable.

So far, the only practical use of this *surréaliste* device was in a series of films of normal speech made in collaboration with Dr. John Lotz of Columbia.[3] The larynx, pharynx, soft palate, and most of the tongue are shown by roentgen ray, but the nose, lips, and chin by surface lighting. An enlarged frame from one of the lateral views is shown in Figure 2.

ADAPTATION OF MOTION PICTURE CAMERAS TO HIGH SPEED LENSES

Photographic objectives with apertures greater than f/1 seldom provide much working distance between the rear element and the focal plane. The Petzval type R-Biotars formerly made by Zeiss were exceptions to this rule; but the more modern f/0.75 Fluro-Ektar (back focus about 7 mm.) and the f/0.71 Wray lens (back focus 2.2 mm.) leave barely enough room for a thin aperture plate and none at all for a behind-the-lens shutter. There are two ways around the shutter problem. One is to do without the shutter and trust to an extra rapid pulldown mechanism to move the film so quickly past the aperture that "streaking" of the image in negligible.[1] The other is to retain the conventional film movement and relocate the shutter farther forward, the exact position depending on the design of the lens.

It so happens that the rearmost glass element of the Fluro-Ektar is a field flattener, separated from the body of the lens by an interval of several centimeters.In the arrangement shown in Figure 3, the

Fig. 2. Enlarged frame from motion study of normal speech taken at 30 frames per second. Movements of larynx, pharynx, soft palate, and posterior tongue are shown by roentgenography; those of lips by conventional photography.

field flattener has been partially sunk in a threaded recess in the camera aperture plate, leaving room for the relocated shutter to revolve between the field flattener and the lens proper. The Wray lens, on the other hand, is so constructed that the only possible place for the shutter is out in front, as shown in Figure 4. Because of the greater diameter of the cone of light which must be interrupted in this position, a single blade, before-the-lens shutter would have to be objectionably large. The shutter and shutter housing in the illustration have been kept within fairly convenient limits by the use of two shutter blades turning in opposite directions.

Fig. 3. Standard Bell and Howell camera fitted with 110 mm. f/0.75 Fluro-Ektar lens. Shutter housing is on front of camera between body of lens and field flattener.

Stereo Projection of Roentgen-Ray Motion Pictures

Stereo cinefluorography was pioneered by Janker in the mid-1930s, and he reports having used it with some success during World War II for localizing shell fragments.[2] His special equipment consisted of two roentgen tubes placed side by side, energized continuously from separate transformers. The two roentgen-ray beams were interrupted alternately by a revolving lead shutter so as to produce first a right-eye image of the subject, then a left-eye image, and so on. For viewing the films, he had a rather primitive 35 mm. stereo projector of the "alternate frame" type with red and green filters.

Janker blamed the shortcomings of his stereo films on the persistence of his fluorographic screen. However, the slight overlap of exposures caused by screen "afterglow" would seem to be a very minor defect in comparison with the gross unsharpness in-

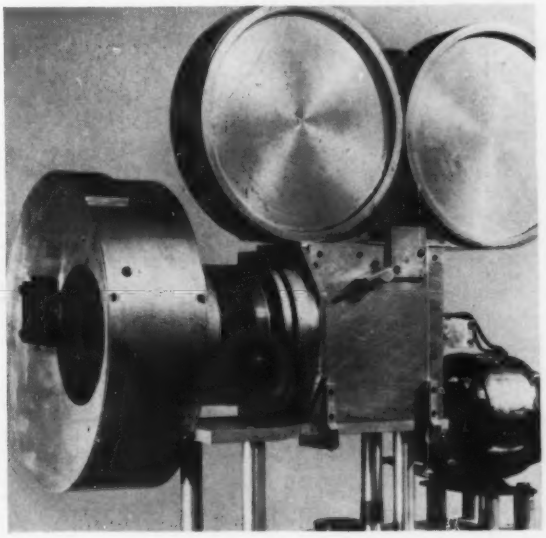

Fig. 4. Special 35 mm. camera fitted with Wray 65 mm. f/0.71 lens. Shutter housing and shutter, consisting of two blades revolving in opposite directions, are located in front of lens.

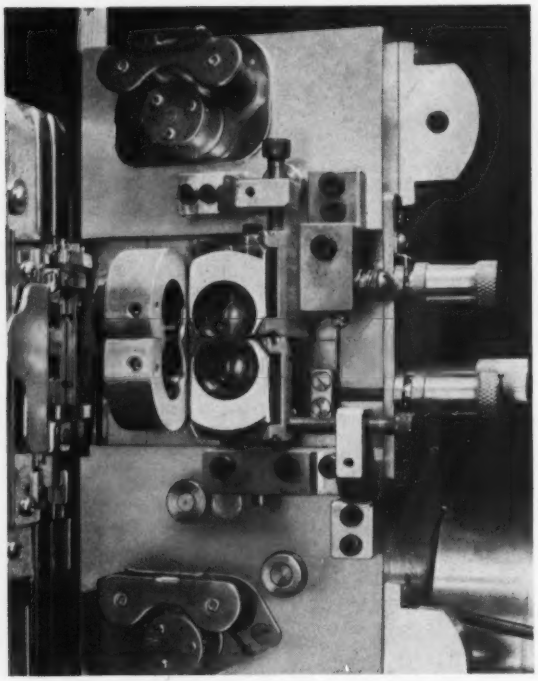

FIG. 5. Close-up view of special stereo projector for rotational films. From left to right: twin picture apertures, matched projection lenses, 45 degree first surface mirrors, and focus and framing adjustment knobs.

herent in the fluorographic technique. Even with subjects of easy penetrability and high contrast, the cinefluorographic image never approaches the sharpness of conventional cinematography, and hence never attains the hoped-for discrimination of detail in depth.

Another source of trouble lies in the fact that the frames which make up the stereo pairs are not exposed simultaneously, as in conventional stereo cinematography, but in sequence. With live subjects this means that there is usually movement (other than stereo shift) between one frame of the pair and the next. Wherever such movement occurs the stereo illusion breaks down locally. Nor does it help matters to view these alternate frames on an alternate frame projector, since the alternate occultation of the spectator's eyes simply introduces one more obstacle to good viewing in the form of "differential flicker."[4]

Our own experiments, in 1952, with "twin tube" stereo were not encouraging.[6] The unavoidably wide separation between the two roentgen-ray sources (about 15 cm. with rotating anodes) caused excessive stereo image displacement when used at routine cinefluorographic target-screen distances (75 to 90 cm.). Accordingly we abandoned the alternate tube principle in favor of the rotational principle, which, in its simplest form, consists of revolving the subject continuously between the roentgen-ray source and the fluorographic screen. The first motion picture exposure "arrests" the turning subject in position A, the second in position B, and the third in position C, and so on. The stereo pairs of frames may then consist either of frames 1 and 2, 2 and 3, 3 and 4, etc., or of frames 1 and 3, 2 and 4, 3 and 5, etc.

One advantage of rotational films is that they can be run on ordinary projectors. Binocular stereo viewing adds little to their scientific value, though it does provide gross orientation in depth for spectators who are unfamiliar with roentgen-ray anatomy. If a stereo projector of the alternate frame type is used, a single print of the film sufficies, and the stereo pairs will consist inevitably of frames 1 and 2, 2 and 3, 3 and 4, etc. On the other hand, if a twin stereo projector is used, two prints are needed, and these can be threaded out of step by any desired number of frames.

In a sense the two film channels of the twin projector are wasted on rotational films, since the two projection prints are identical, and are only transformed into stereo pairs by staggered projection. This can be accomplished equally well by runing one print in a single channel projector having two picture apertures arranged in tandem. Such a projector is illustrated in Figure 5. The two apertures are one frame apart, so that the stereo pairs, which appear simultaneously on the projection screen (superimposed, but polarized in opposite planes), consist of frames 1 and 3, 2 and 4, 3 and 5, etc. Since there is no "differential flicker" problem whith this projector, rotational fims can be projected in stereo

Fig. 6. Frames from 70 mm. motion study of wrist made by direct cineroentgenography at 15 frames per second. Note superior bone detail.

at considerably slower speeds than they can by the alternate frame method.

It may be worth mentioning that conventional motion pictures, including color pictures, often give a quite good stereo effect on the twin aperture projector. This is especially true of views taken from a smoothly moving train or boat.

DIRECT CINEROENTGENOGRAPHY ON 70 MM. FILM

The 70 mm. motion picture camera developed here in 1951–1952[5] was designed primarily for cinefluorography, but has recently been adapted for direct cineroentgenography by simply reducing the thickness of the original camera aperture plate and thus bringing the subject close to the film plane. The frame is roughly 2 inches square (53×57 mm.). By using double-coated 70 mm. negative film (Kodak "no screen" x-ray safety film, 5133), roentgen-ray motion studies of such subjects as small animals and parts of animals, small children's elbows, knees, and ankles, and adult fingers, toes, wrists, etc., can be exposed at 15 frames per second without excesssive roentgen-ray dosage. A pair of intensifying screens would, of course, increase the roentgenographic speed of the unit by many times, but the installation of screens presents difficulties. Experiments are being made with a single intensifying screen and single-coated film. Meanwhile, the no screen film gives excellent detail with subjects of thin cross section, as shown in Figure 6.

SUMMARY

This paper describes briefly the following developments in the field of roentgen-ray motion pictures: (1) A special, flicker-free, slow speed projector for analyzing cinefluorographic films. (2) A method for combining cinefluorography with conventional cinematography. (3) The adaptation of motion picture cameras to ultra high speed lenses. (4) A special stereo projector for cinefluorographic films taken by the rotational method. (5) Direct cineroentgenography on 70 mm. film.

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Vol. 75, No. 1

SCREEN INTENSIFICATION: A REVIEW OF PAST AND PRESENT RESEARCH WITH AN ANALYSIS OF FUTURE DEVELOPMENT*

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I. INTRODUCTION

SEVEN years ago at the annual meeting of the American Roentgen Ray Society, the first symposium on the subject of fluoroscopic screen intensification was presented. On this occasion, several investigators reported for the first time, work which indicated that the development of clinically practical screen intensifiers was not far away. History, of course, since 1948 has borne out the cautious optimism expressed at this early symposium. Commercially available screen intensifiers have become a reality, and although they have not yet been widely used, there is every reason to believe that they will be when improvements in design are forthcoming.

It is not known when the need for screen intensification in the field of diagnostic roentgenology was first recognized. Almost certainly, the early pioneers at the beginning of this century were frequently annoyed by the fact that their fluoroscopic screens yielded much less diagnostic information than their roentgenographic plates; many probably related this fact to the low brightness levels of the screens. At least, some of the early electronic research in this country was directed toward the development of increasing screen brightness. In the United States Patent Office, sketches, dated about 1915, are on file which show an electronic system whereby screen brightness can be increased. It is interesting, in this connection, that these sketches disclose a new all-electronic system of television which has since become the basis of present-day television. The proposed techniques did not have immediate application to radiology, since the science of electronics had not advanced sufficiently. However, they make it clear that, from a historical standpoint, considerable thought was given to increasing the brightness of the fluoroscopic screen at least forty years ago.

During the 1920's and 1930's, little progress was made in the devolopment of research programs on screen intensification. It is true that the manufacturers of fluorescent screens were continually improving the efficiency of their products by small increments. Also, when radiologists met in informal discussions, the subject of screen intensification was frequently considered. A perusal of my files recently revealed correspondence with Dr. Paul C. Hodges in the late 1930's on methods to brighten the fluoroscopic image. However, it was Chamberlain's monumental Carman Lecture[1] in 1941 which brought into focus finally the serious physiological disadvantages under which radiologists operate when performing conventional fluoroscopy, and the many benefits which would ensue if methods to brighten fluoroscopic screens by factors of several thousands of times could be designed.

Chamberlain demonstrated that roentgenograms made with fluoroscopic screens in contact with film exhibit much more detail than the same screens when used in fluoroscopy. A few years before, Hecht[3,4] had shown that the human eye, when viewing fields having a brightness approaching that encountered in fluoroscopy (10^{-4} to 10^{-2} millilamberts) had a visual acuity, or ability to perceive detail, of only a small fraction of that occurring under normal lighting conditions (10 to 100 millilamberts). Chamberlain, therefore, reasoned that the poor performance of the fluoroscope may be attributed to deficiencies of

* Presented at the Fifty-sixth Annual Meeting of the American Roentgen Ray Society, Chicago, Illinois, September 20–23, 1955.

the human eye when operating at the low levels of illumination which exist during fluoroscopy rather than to any inherent imperfections in the fluoroscope itself and that this performance should be improved many times if the brightness of the screen were increased to levels at which the eye performs more satisfactorily. As a result of Chamberlain's discussion, interest in the subject of screen intensification was given an enormous impetus and experimental work was undertaken in a number of laboratories in this country and abroad soon after the end of World War II to develop practical screen intensifiers.

II. THEORY OF SCREEN INTENSIFICATION

Before these research developments are described, it may be well to review, briefly, the fundamental principles of fluoroscopic vision, for it is on these principles that the future of screen intensification seems so promising. At the outset, it may be said that, although the conclusions which may be drawn from the work of Chamberlain and Hecht are quite encouraging from the standpoint of the benefits to be derived from screen intensification, the premise that an improvement in fluoroscopic clarity will surely follow an increase in brightness of the fluoroscopic screen should not be wholly accepted until it is certain that the causes of the poor visual acuity which occurs at low levels of illumination will not also influence the performance of any man-made optical device which may be used to increase screen brightness. It is entirely possible that the limitations of the human eye are caused by factors which also limit all types of optical systems, physical as well as physiologic. If this is the case, the use of an intensifying device in conjunction with the fluoroscope will make little if any improvement in screen clarity.

It will be well to ask what are the factors which control the clarity of fluoroscopic vision. Over the years, there has accumulated a copious literature which indicates that these factors include the grain size of the fluoroscopic screen, the geometric unsharpness of the roentgen-ray beam, as well as the characteristics of the human eye. Although all of these factors impose limitations on the clarity with which fluoroscopic images are visualized, there is yet another factor which is even more fundamental.

The images appearing on a fluoroscopic screen are produced by the projection of a roentgen-ray beam through the anatomical structure which one wishes to visualize. Such a beam is composed of myriads of photons or roentgen-ray quanta. On passing through the anatomical structure, many, and sometimes most, of these photons are absorbed by the structure; some, however, pass through to emerge on the other side and thence to fall on the fluoroscopic screen. In the screen, these roentgen-ray photons are converted into light, whereupon they may be observed.

If all anatomical tissues absorbed roentgen-ray photons equally, the number of photons emerging to fall on the fluoroscopic screen would be uniform from one portion of the screen to another and hence the light generated by the screen would have no image pattern whatever. Fortunately, however, some tissues absorb more roentgen-ray photons than others, and hence the brightness of the fluoroscopic screen is not constant from one point to another but instead varies in accordance with the configurations of the anatomical structures through which the radiation has passed. In this way, the light emitted by the fluoroscopic screen bears an image pattern.

From this description of the manner by which fluoroscopic images are produced, it will be clear that the diagnostic information provided by a fluoroscopic image is carried from the patient to the screen by the myriads of roentgen-ray photons which comprise the roentgen-ray beam. Indeed, each photon which is transmitted from the patient to the screen carries a certain small amount of diagnostic information and it is the sum of all of the increments of information carried by these photons which controls the total quantity of diagnostic information provided by the screen at any in-

stant. The amount of information provided by the screen can never be greater than that carried by the photons which impinge on it. The amount of information, of course, can be less, if such factors as grain size and geometric unsharpness do not permit efficient utilization of the information carried by the photons. The point that must be emphasized, however, is that the diagnostic information provided by a fluoroscopic screen can be no greater than the sum of all of the increments of information carried to the screen by the photons of the roentgen-ray beam. Since the quantity of diagnostic information provided by a screen is a measure of the screen's clarity, it is evident that fluoroscopic clarity is a function of the number of roentgen-ray photons falling on the screen during the fluoroscopic process.

Since each roentgen-ray photon may be assumed to have associated with it a certain amount of diagnostic information, it follows that when a roentgen-ray beam of high intensity is projected through a patient, the clarity of the fluoroscopic images will be considerably greater than when a beam of low intensity is used. In the first instance, there are a great many roentgen-ray photons carrying diagnostic information to the screen and hence the clarity of the resulting images is relatively good; in the second instance, the number of roentgen-ray photons is smaller and hence less diagnostic information is brought to the screen with resulting degradation of image quality.

From this discussion, it may be reasonably concluded that if one wishes to see more at fluoroscopy, one need only increase the milliamperage applied to the roentgen tube. Experience proves that such a conclusion is entirely valid. Indeed, if one operates a fluoroscope at 50 milliamperes instead of 5 milliamperes, the detail which can be perceived on the screen is considerably greater. Perhaps such an experiment proves better than in any other way the fact that grain size in the fluoroscopic screen is not a fundamental controlling factor affecting clarity of detail. If grain size were the controlling factor, the increase in milliamperage from 5 to 50 milliamperes would not have produced any change in visible detail whatever.

The question may now be asked as to what will happen to fluoroscopic clarity if one brightens the screen, not by increasing the milliamperage of the roentgen tube, but by introducing into the fluoroscopic process a screen intensifier of one sort or another. On the basis of the preceding discussion, it would appear that no increase in clarity should occur. Even if the fluoroscopic screen is made brighter by a screen intensifier, the fact that the milliamperage on the roentgen tube, and hence, the number of roentgen-ray photons which take part in the fluoroscopic process are not increased, indicates that no more diagnostic information is carried from the patient to the screen and hence no improvement in screen clarity can be expected. The only circumstance under which this reasoning will not be valid is one which occurs if the eye under the conventional fluoroscopic process does not utilize 100 per cent of the information transmitted from the patient to the screen by the roentgen-ray beam's photons. Under such a circumstance, it might be possible by means of a screen intensifier to improve conditions in such a way that greater utilization of photon information could be effected.

On the basis of measurements made by Sturm and Morgan[11] in a study of optical physiology as it relates to fluoroscopy, it appears that the human eye, during conventional fluoroscopy, utilizes the diagnostic information of only a small fraction (about 1 to 5 per cent) of the roentgen-ray photons received at the screen. Hence, if it were possible, by the introduction of a screen intensifier, to improve the efficient utilization of these photons, a considerable improvement in the diagnostic clarity of fluoroscopy could be developed. For example, an improvement in the efficiency of the fluoroscopic process from 2 per cent to 100 per cent would effect an improvement in screen detail equivalent to that produced by an increase in the roentgen tube current

from 5 milliamperes to 250 milliamperes. We know by experience that the improvement in detail with such a change in milliamperage is indeed very great. It, therefore, is evident that the introduction of a screen intensification system which improves the efficiency of fluoroscopic vision will also improve fluoroscopy very materially.

It must be emphasized that the introduction of a screen intensifier into the fluoroscopic process will, under no conditon, improve the clarity of fluoroscopic vision if it only increases the brightness of the fluoroscopic screen without increasing the efficiency of roentgen-ray photon utilization over that which occurs at conventional fluoroscopy. Indeed, if at conventional fluoroscopy, the eye utilized 100 per cent of the information carried from the patient to the screen by roentgen-ray photons, no improvement in fluoroscopic clarity could be expected under any circumstances. It is only the fact that the eye utilizes a small fraction of the information carried by the roentgen beam that screen intensification holds promise of success. Fortunately, the evidence from studies in optical physiology[10,11] indicates that screen intensification has a considerable opportunity to improve fluoroscopic efficiency and we can confidently expect fluoroscopy with screen intensifiers to yield a degree of clarity which approaches and in some instances exceeds that of roentgenographic film.

III. DEVELOPMENTAL RESEARCH

Since the end of World War II, considerable progress has been made toward the development of practical instruments whereby the luminance of fluoroscopic screens may be increased or intensified. The instruments which have been developed fall into three broad categories: (a) instruments which employ simple electron optical systems;[2,9] (b) instruments which use storage-type televison circuitry;[7] and (c) instruments which are based upon the flying-spot principle of televison.[6]

(*a*) *Electron optical intensifiers.* Screen intensifiers of the simple electron optical

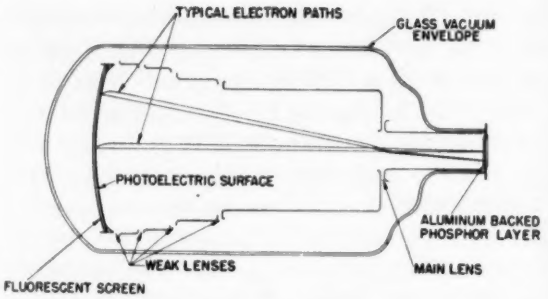

FIG. 1. Schematic diagram of Westinghouse screen intensifier. (Reproduced by courtesy of Westinghouse Electric Corp.)

type are shown schematically in Figure 1 and 2. The first is the instrument currently being manufactured by the Westinghouse Electric Company in this country and the second is the intensifier being produced by the Philips Company of Holland. Each of these devices consists of an evacuated tubular glass envelope in which are located a more or less conventional fluorescent screen at one end of the tube and an aluminum-backed phosphor layer at the other. The inner surface of the fluorescent screen is covered with a thin photoelectric layer and, between the screen and phosphor, are placed a number of cylindrical electrodes which serve as electron lenses when suitable electric potentials are applied to the photoelectric layer, the electrodes and the phosphor. The intensifier operates in the following manner: Radiation from a conventional roentgen tube is projected through the patient and is allowed to impinge on the instrument's fluorescent screen. In response to the light generated

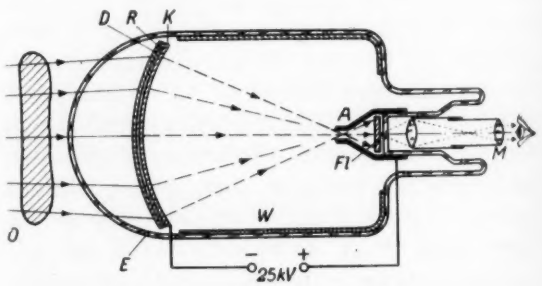

FIG. 2. Schematic diagram of Philips screen intensifier. (Reproduced from *Acta Radiologica.*)

by the screen, the photoelectric layer emits electrons having a spatial distribution proportional to the brightness of the screen. That is, the fluorescent screen converts the roentgen-ray image into a light image whereupon the photoelectric layer creates a corresponding electron image. The electrons from the photoelectric layer are accelerated down the length of the tube under the influence of the electric potentials applied to the cylindrical electrodes and fall on the phosphor at the tube's distant end. The impingement of the electrons on this phosphor produces a visible image which duplicates the pattern of that appearing on the roentgen-ray fluorescent screen. However, due to the acceleration of the electrons within the tube, the brightness of the phosphor is many times greater than that of the screen. The brightness is further increased by the fact that the size of the phosphor is small compared to that of the fluorescent screen. The observer views the intensified image appearing on the phosphor by means of a telescopic eye piece or other optical system to bring the size of the image back to normal perspective.

The advantages of electron optical intensifiers are their great simplicity, their relatively low cost, and, above all, their theoretical ability to improve the efficiency of the fluoroscopic process from the standpoint of the observer's ability to see to a level closely approaching 100 per cent. The quality of image rendition in these tubes is therefore excellent, particularly in examinations of the chest and extremities. Their disadvantages include a somewhat limited increase in brightness over conventional screens (500 to 1,500 times), a small field size (5 inches in diameter), a low inherent contrast (about the same as that of conventional fluoroscopes as opposed to the much higher contrast of roentgenographic films) and a tendency to undergo deterioration in image quality during the examination of thick structures due to fogging of the viewing phosphor by spurious electron emission from within the tube. Another disadvantage experienced by some workers

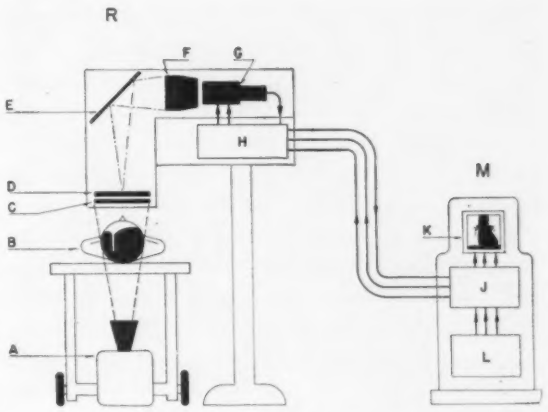

Fig. 3. Schematic diagram of television-type screen intensifier. (*A*) Fluoroscopic roentgen-ray generator; (*B*) Patient under examination; (*C*) Wafer grid; (*D*) Fluoroscopic screen; (*E*) Plane mirror; (*F*) High speed lens; (*G*) Image orthicon; (*H*) Preamplifier; (*J*) Final amplifier; (*K*) Viewing screen (cathode-ray tube or kinescope); (*L*) Pulse former for generating electrical pulses to sweep the electron beams of the image orthicon and kinescope synchronously with one another.

is one's need to view the intensifier through an optical device; freedom of motion for the observer is therefore rather confined. Although these disadvantages are sometimes bothersome, it is the general feeling of those who have worked extensively with electron optical intensifiers that their advantages far outweigh their defects and that these instruments constitute a marked step forward in the solution of the screen intensifier problem.

(*b*) *Storage-type television intensifiers.* The details of a typical intensifier using storage-tube television circuitry is shown schematically in Figure 3. This instrument, like the intensifiers of the electron optical type, employs a conventional roentgen tube, the radiation of which, after projection through the patient under examination, falls on a conventional fluoroscopic screen. The light from this screen is focused by a lens system on the sensitive surface of an image orthicon (the photosensitive tube employed in many television cameras in this country). In response to the light falling on its sensitive surface, the image orthicon generates an electrical signal

which, after amplification, is impressed on the control grid of a cathode-ray tube whose electron beam is swept systematically over the surface of the tube synchronously with the electron beam within the image orthicon. Hence, there appears on the surface of the cathode-ray tube a fluoroscopic image of the patient. Due to the amplification which takes place within the instrument, the brightness of the fluoroscopic image is many times that normally seen on conventional fluoroscopic screens.

The advantages of the storage-type television intensifiers are the relatively large gain in screen brightness (up to 50,000 times the brightness of conventional screens), a screen size that can be tailored to almost any need (sizes as large as 3 feet square have been used for some industrial applications), high and controllable image contrast (equal to and exceeding roentgenographic film), the absence of special optical devices for viewing the intensified image, and the independence of the viewing unit's location relative to that of the radiation detector unit. The disadvantages include relatively great complexity of design, comparatively high cost and an efficiency in utilization of roentgen-ray photons of less than 100 per cent. Complexity of design and cost have limited the application of this type of intensifier to some extent. However, when these factors are unimportant, the storage-type television intensifier has proved itself quite useful in a number of problems which cannot be solved either by conventional fluoroscopy or by electron optical intensifiers.

(*c*) *Flying-spot television intensifiers.* Very little success has been experienced by workers who have been exploring the flying-spot type of television intensifier. The extremely low efficiency with which roentgen-ray power is utilized by this device makes it seem unlikely that it will have practical application in the foreseeable future.

IV. APPLICATIONS

Since screen intensifiers have been available for only a short time, their application has, of course, been limited. A number of radiologists have been using intensifiers of the electron optical type in conventional fluoroscopy and most are enthusiastic about their performance.

Probably the area where screen intensification has enjoyed the greatest activity during the past two or three years is the field of cinefluorography. Until the advent of screen intensification, cinefluorography was extremely limited as a practical procedure due to the enormous radiation dosages to which patients were exposed unless very short sequences were performed. With screen intensification, however, this difficulty has been overcome so that motion pictures of long roentgenologic sequences can be undertaken with radiation exposure to the patient of no more than that employed during conventional fluoroscopy. Also, since the screen intensification process is inherently efficient in its utilization of available roentgen-ray energy, the quality of cinefluorograms made with screen intensifiers is usually equal to or greater than that of films made with older, less efficient techniques, even though the latter uses much more radiation. At the present time, there is much interest in cinefluorography in this country and abroad and it is expected that the technique will be widely used in the study of many physiological problems. Intensifiers of both the electron optical and television types are being used in this application and both are providing good service.

The ability of one to separate the viewing unit from the radiation detector to almost any desired distance in intensifiers of the television type has made these devices unusually suitable to a number of applications. In industrial radiography, where for protective reasons it is desirable to place the observer remote from the radiation source, these instruments have proved quite useful. In time, this feature may well prove worthwhile in medical fluoroscopy. For example, in radiation therapy, television-type intensifiers have been used successfully as a beam localizing fluoroscope[8] with the radiotherapist observing the

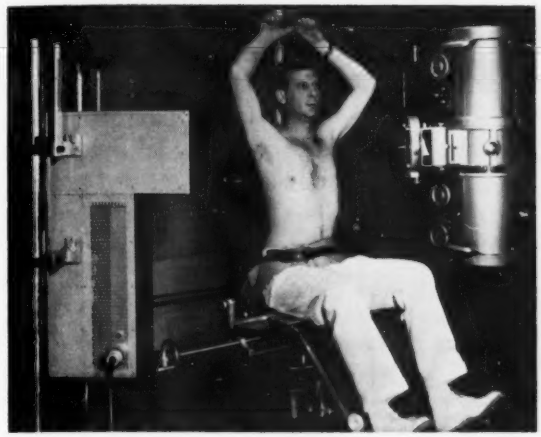

Fig. 4. Application of screen intensification to roentgen therapy. Apparatus permits precise localization of radiation to desired region of treatment.

Fig. 5. Projection kinescope for demonstration of fluoroscopy to large audiences.

screen in safety in the control room outside of the therapy area. Such an application is shown in Figure 4.

Screen intensifiers of the television type are also of considerable usefulness in teaching. With this instrument, it is possible to attach additional viewing units and television projectors by which fluoroscopy can be presented clearly to large groups of students and physicians (Fig. 5). This application is one which seems likely to be increasingly adopted as time goes on.

FUTURE DEVELOPMENTS

With screen intensification just beginning to become a significant force in the field of radiology, the question arises as to what may be expected in the future. In the field of instrumentation, work is in progress in a number of laboratories which indicates substantial improvements in equipment will be forthcoming in the next few years. Much effort is being directed toward the development of electron optical intensifiers with larger field coverage (10 inches or more). Research is also going on in at least two laboratories in this country on the development of television-type detector tubes which are directly sensitive to roentgen rays as opposed to present day tubes which operate from light from an external fluorescent screen. When these roentgen-ray sensitive tubes are available, intensifiers of the television type will be greatly reduced in complexity, and their efficiency should approach the 100 per cent level characteristic of intensifiers of the electron optical type.

Current research may also produce types of intensifiers which are quite different in design than those now available. The electroluminescence properties of some phosphors are being studied, particularly at the General Electric Company, and it seems probable that relatively simple screens no more bulky than conventional screens and providing brightness gains of 5 to 25 times may be possible to design. Electroluminescence[5] is the property of some fluorescent materials to increase in brightness when placed in an alternating electric field; such a field can be produced by two sheets of conducting glass placed on either side of the fluorescent screen and connected to a suitable potential a.c. source.

From the foregoing, it is clear that much is to be expected from research during the next few years in the development of new and improved intensification devices. These developments will probably be evolutionary rather than revolutionary, and they may be expected to extend the usefulness of present day intensifiers rather than replace them.

If the future of instrumentation in the field of screen intensification appears to be one of expanding growth, such growth will

perhaps be dwarfed by that which should take place in the medical and industrial applications of these devices. The application of screen intensification techniques to the study of many physiological problems can be confidently expected. Stauffer in Philadelphia and Miller in San Francisco as well as several others are already hard at work in this field. In radiation therapy, in radiologic teaching and in industrial radiography, considerable growth in screen intensification techniques will almost certainly take place. Of course, it may also be confidently expected that screen intensifiers of one type or another will supplant conventional fluoroscopic screens within the next decade or two.

Like any research development which promises to have an enormous influence on a given branch of science, screen intensification, its techniques and the knowledge gained therefrom are likely to prove valuable in a variety of corollary scientific areas. For example, the light-sensitive section of a television-type intensifier has been used recently at the Lowell Astronomical Observatory at Flagstaff to yield photographs of the planets of considerably greater detail than those heretofore taken under similar conditions. The same apparatus has also been used to permit the photography of night scenes, illuminated only with starlight, with conventional film and lenses at the unusually short exposure time of 0.1 second. Electronic research in the extremely low ranges of light intensity which has been needed to solve the problems of screen intensification seems likely to prove equally useful in many scientific, industrial and military applications beyond the boundaries of radiology.

Such, then, is screen intensification in 1955, as seen from the limited perspective of one observer. It seems unlikely that the views expressed here will have any long-standing value, but if they do, it will probably be to illustrate how incompletely one man can grasp the significance of developments going on about him in an enormously expanding science.

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ELECTROLUMINESCENCE AND LIGHT-AMPLIFYING PHOSPHORS APPLIED TO FLUOROSCOPIC IMAGE INTENSIFICATION*

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THE need for amplification of the brightness of the fluoroscopic image has been known for some time. Chamberlain[1] stressed the need for brightness amplification of 10,000 to 30,000 in fluoroscopic work in order to permit the human eye to have the visual acuity and intensity discrimination feasible in fluorographic work. Sturm and Morgan[17] utilized fluctuation theory in demonstrating that the number of roentgen-ray photons absorbed by the intensifying device sets a fundamental limit to the magnitude of useful brightness amplification. They concluded that the maximum improvement in visual acuity and contrast involves intensifiers with 30 to 50 gain; however, gains of 500 and 1,000 are desirable to avoid the inconvenience of dark adaptation. An obvious inefficiency of fluoroscopy compared to fluorography is that the eye collects only over a small solid angle the light from an element of the fluoroscopic screen whereas the photographic plate in intimate contact with the screen collects over a solid angle of 2π. Brightness amplification is certainly desirable to the extent that the eye collects with a given roentgen-ray dosage the same number of light quanta from an element of the fluoroscopic screen as does the photographic plate in fluorography. We conclude, therefore, that amplification of the brightness of fluoroscopic images is important for visual acuity, intensity discrimination, and convenience in minimizing dark adaptation. Morgan et al.[10] have pointed out the use of image amplifiers in radiation therapy, as well as for diagnostic roentgenology.

During the past decade four electronic methods of fluoroscopic image intensification have been explored: (1) Moon[9] has described a system comprising a scanning roentgen tube which scans the patient with a beam of roentgen rays; the light from the fluoroscopic screen is picked up by a photocell, and the photocurrent is amplified and displayed on a television screen. This method suffers from the difficulty of fabricating a scanning roentgen tube of adequate intensity. (2) Morgan and Sturm[11] have had operating a closed-circuit television camera and receiver system. The fluoroscopic screen image is focused by a Schmidt optical system onto an image orthicon. The output of the image orthicon is amplified and displayed on a television screen. The electronic gear associated with this system is rather extensive. (3) The image tube has been extensively investigated by several industrial laboratories.[2,8,18] The roentgen rays impinge on a fluoroscopic screen in a vacuum tube; the light photons from the screen free electrons from a contiguous photoemitter; the photoelectrons are accelerated and focused as a demagnified image on a small cathodoluminescent screen. Viewing through a suitable optical system re-establishes fluoroscopic screen image size without loss of the increased brightness. The intensification arises from the large energies (25,000–30,000 ev.) given to the photoelectrons and from the increase in the electron concentration during the electronic demagnification step. (4) Simplified and more sensitive television cameras similar to the photoconducting Vidicon tube have recently been shown to respond to roentgen rays.[3,7] The roentgen rays impinge directly onto a

* Presented at the Fifty-sixth Annual Meeting of the American Roentgen Ray Society, Chicago, Illinois, Sept. 20–23, 1955.

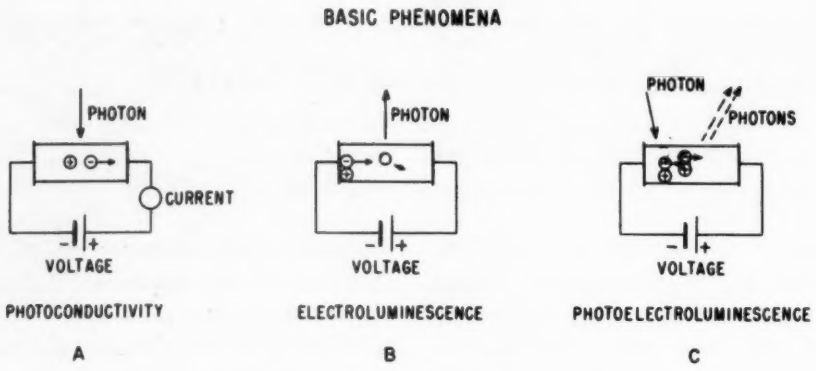

FIG. 1.

dielectric layer which is being scanned and charged by an electron beam; the dielectric becomes conducting under the influence of the roentgen rays, and the current is amplified and displayed on a television receiver.

The electronic methods of image intensification are particularly suitable for large roentgenologic installations and for applications where observation remote from the irradiation is necessary. However, it is abundantly clear that there still exists a need for the ideal screen intensification system[12] which satisfies the criteria: (1) simple in use, (2) clear in performance, and (3) inexpensive. The recent advances in the physics of the solid state indicate that this need may be met with a system not utilizing vacuum tubes but involving a modest voltage applied to a special screen similar in dimensions to an ordinary fluoroscopic screen.

BASIC PHENOMENA FOR SOLID-STATE IMAGE INTENSIFICATION

A phenomenon basic to the simplified television system (electronic method 4 of preceding section) and to one of the solid-state systems (method 1 of following section) for fluoroscopic image intensification is the phenomenon of enhanced conductivity of a dielectric when exposed to roentgen rays.[6] The roentgen-ray photon is absorbed in the dielectric and creates an electron with large kinetic energy. The primary electron then creates by inelastic collisions a multitude of conduction electrons. In addition, the positive space charge concurrently formed may facilitate more conduction electrons traversing the dielectric. Figure 1*A* illustrates the phenomenon of

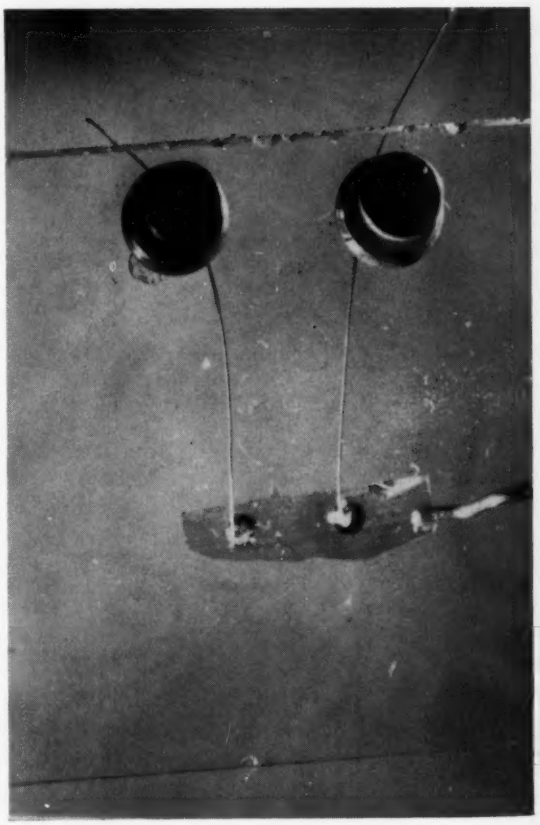

FIG. 2. Electroluminescent zinc sulfide single crystal complete with metal electrode.

photoconductivity. The large number of conduction electrons per absorbed roentgen ray is the basis for sensitivity and amplification.

Electroluminescence is a phenomenon basic to all four schemes for solid-state fluoroscopic image intensification described in the following section. In this process electrical energy is converted into light by applying a voltage to a crystalline solid at room temperature. Destriau[5] reported the electroluminescence of sulfide phosphors. An a.c. electrical potential was applied to a suspension of phosphor particles in a liquid between plane parallel electrodes. Improved electroluminescent cells using solid dielectrics as the matrixes for the phosphor particles have been reported.[13,16] In addition, electroluminescence has been investigated in continuous films and single crystals of zinc sulfide. The experimental work on single crystals, such as shown, complete with metal electrodes, in Figure 2, has aided in the theoretical understanding of electroluminescence.[14] Theoretically, the direct conversion in a semiconducting phosphor of electrical energy into luminescence may occur by several mechanisms depending on local field conditions and energy band structure[15]: (1) The impurity responsible for the luminescence may be field ionized directly. On subsequent capture of a conduction electron, light emission occurs. This mechanism requires local fields of 10^7 v/cm. and has yet to be reported experimentally in the literature. (2) Minority charge carriers may be injected through a barrier, and recombination with the majority charge carriers either directly or at a suitable impurity yields light emission. The direct process has been reported for cadmium sulfide, whereas the impurity recombination process occurs in silicon carbide. (3) Conduction electrons may be created in a high-field region by field ionization of bound electrons, and if the field is adequate, the conduction electrons have appreciable probability of being accelerated to kinetic energies so that inelastic collisions with impurities occur. Appropriate impurities are thereby excited and then light emission occurs. This mechanism is sketched in Figure 1*B*. The electroluminescence of zinc sulfide occurs by the collision excitation mechanism.

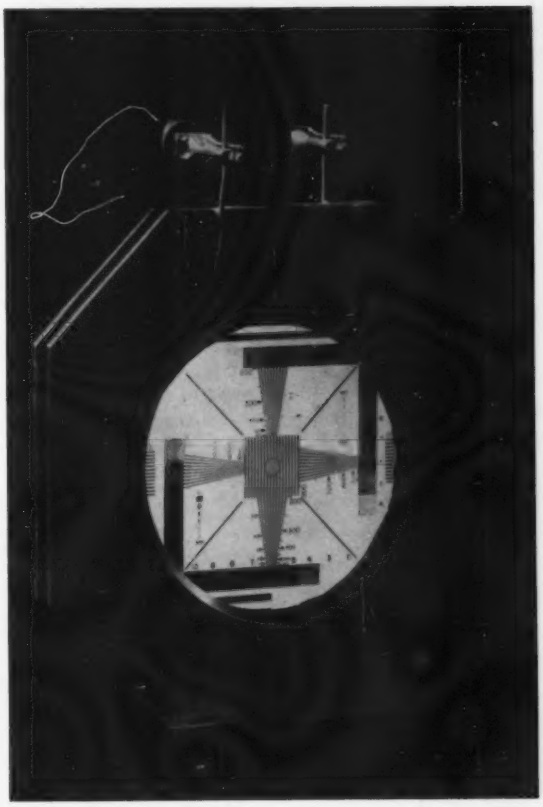

Fig. 3. Intensified image on light amplifier screen.

Photoelectroluminescence is the dominant phenomenon in two of the solid-state schemes for fluoroscopic image intensification described in the following section. In this process electroluminescence is controlled by incident radiation. The theoretical understanding of the sequential events required for electroluminescence by the collision excitation mechanism indicated the possibility of the creation of the conduction electrons in the high-field region by an internal photoelectric effect, followed by acceleration and multiplication to yield light emission with radiation amplification.[20] These processes are shown diagram-

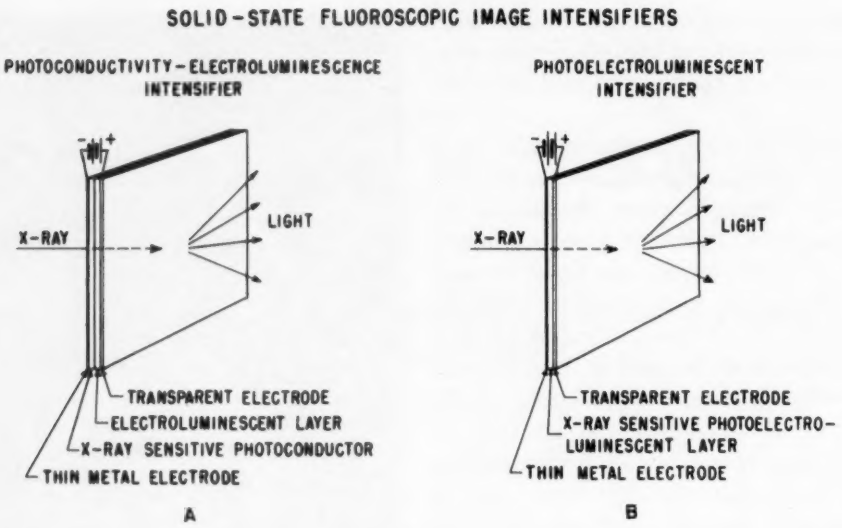

FIG. 4.

matically in Figure 1*C*. Cusano[4] reported photoelectroluminescence in manganese-activated zinc sulfide. Approximately 100 volts d.c. is applied across a 10 micron phosphor film. With incident ultraviolet rays the quantity of emitted radiation has been measured and found to be ten times the quantity of incident radiation. Radiation amplification in a simple phosphor film has been, therefore, demonstrated. Since the light emission is proportional to the incident radiation, image contrast is preserved during the intensity amplification. These effects are demonstrated in the projected image on the light amplifier in Figure 3. With incident roentgen rays, strong enhancement of the emission by the applied voltage is observed, and although the thin phosphor film absorbs the roentgen rays much less strongly than an ordinary fluoroscopic screen, the brightness is somewhat greater. Thicker roentgen-ray sensitive amplifying phosphor films, photoelectroluminescent screens sensitive to visible radiation, and greater radiant energy amplification are believed feasible.

It should be emphasized that the phenomena of roentgen-ray sensitive photoconductivity, electroluminescence, and photoelectroluminescence occur in thin screens similar in gross dimensions to ordinary fluoroscopic screens.

SOLID-STATE METHODS FOR FLUOROSCOPIC IMAGE AMPLIFICATION

A method of obtaining increased fluoroscopic screen brightness by well-known solid-state elements has been described by White.[19] This method involves an electroluminescent cell contiguous to a dielectric layer whose impedance markedly decreases under the influence of roentgen rays. The two layers are in series electrically. An incident roentgen ray impinging on an element of the screen results in an increased fraction of the total applied voltage across the electroluminescent cell at that particular element. Since electroluminescent brightness is a pronounced function of voltage, the light emission at that element of the screen will markedly increase. With suitable matching of the impedances of the roentgen-ray sensitive conducting layer and of the electroluminescent layer, increased fluoroscopic screen brightness should be feasible. The photoconductivity-electroluminescence intensification system is illustrated in Figure 4*A*. Incidentally, this scheme has some features in common with the roentgen-ray sensitive Vidicon tube scheme discussed earlier. It differs, however, in that the electroluminescent cell replaces the Vidicon vacuum tube, except for the roentgen ray conductivity-sensitive

layer, and also replaces the electronic amplifiers and the television receiver.

A variation on the above scheme might involve using the output of an ordinary fluoroscopic screen as the input into a photoconductor which is in series electrically with an electroluminescent cell.

The most elegant solid-state fluoroscopic image intensification system in principle involves a single layer—a photoelectroluminescent phosphor sensitive to roentgen rays. The incident roentgen rays are strongly absorbed and control the conversion into light of the electrical energy from a modest applied voltage. This system is illustrated in Figure 4*B*.

A currently more feasible scheme related to the above involves using the output of either an ultraviolet-emitting fluoroscopic screen as the input into available light-amplifying phosphor films or using the output of the ordinary blue-emitting fluoroscopic screen as the input into light-amplifying phosphor films sensitive to blue light.

Incidentally, although these intensification screens are obviously most suitable for direct observation, remote observation is also facilitated since either simple optical methods or simplified closed-circuit television methods could be used on the intensified image from a successful solid-state fluoroscopic image amplifier.

CONCLUSIONS

The need for amplification of the brightness of the fluoroscopic image is generally appreciated. During the past decade electronic methods of image intensification have been explored, have been moderately successful, but have not become generally used in diagnostic and therapeutic roentgenology.

A solid-state system for amplifying the brightness of the fluoroscopic image offers several advantages over vacuum tube systems. Greater simplicity and convenience and lower cost are among these advantages. A solid-state amplifier consists of a thin screen similar in gross dimensions to an ordinary fluoroscopic screen.

As a result of recent research on the control of conductivity in dielectric solids by incident radiation (photoconductivity) and on the conversion in a crystalline solid at room temperature of electrical energy into visible radiation (electroluminescence), and as a result of the discovery of the control of electroluminescence by incident radiation (photoelectroluminescence), several methods for increasing the brightness of fluoroscopic images by solid-state elements only are now believed feasible. Methods currently being investigated are: (1) An electroluminescent cell in series electrically with a dielectric which becomes conductive during exposure to roentgen rays; (2) A light-amplifying phosphor layer in series optically with an ordinary fluoroscopic screen, and (3) A photoelectroluminescent screen sensitive to roentgen rays. It is probable, therefore, that a successful solid-state fluoroscopic image intensifier will be fabricated in the not too distant future.

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HIGH TENSION SWITCH TUBE FOR ROENTGENOGRAPHY*

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IN THE development of modern roentgenographic equipment relatively little attention has been directed towards shortening the duration of exposures. While new timing and contacting methods are available, the principal improvement offered has been more precise control of time-honored exposure intervals. The radiologist can choose from mechanical, electrical, and electronic timing of exposures while the current market offers a choice of mechanical or electronic contacting. As a result of limitations imposed by the 60-cycle alternating current universally available, few manufacturers in the United States provide exposures of less than one cycle (1/60 second) and none offers exposures shorter than one-half cycle, or 1/120 second.

Motion is always a factor in the roentgenologic study of the living patient. It is estimated that in the United States as much as $250,000 a year is lost as a result of undesired movement during roentgenography. Aside from purely economic considerations, however, there is justification for shortening the duration of roentgenographic exposures. Short exposure techniques are of particular value in cardiovascular roentgenology, and especially in angiocardiography. The most cooperative patient cannot stop his heart during a roentgen exposure. Blood within the human heart and major arteries moves at velocities in excess of 50 to 100 cm. per second, one effect of this rapid flow being to impart movement to heart valves. Progress in cardiovascular surgery has created a definite need for roentgenologic visualization of these valves. Since they move rapidly, it follows that their angiocardiographic demonstration can best be achieved through the use of sufficiently short exposures. High energy roentgen-ray sources are generally available and the problem is therefore essentially one of timing and switching.

Accordingly, efforts were directed toward the development of apparatus making possible roentgen exposures of one millisecond duration and utilizing standard generators and rotating anode diagnostic tubes. This report deals with the description, principle of operation, and results that were achieved through the use of a grid-controlled, high tension switching tube connected in series with the roentgen tube. It is emphasized that the method described is but one of numerous possible approaches to the problem.

Justification for approaching the problem of switching in the secondary (high-tension) side of the transformer circuit becomes apparent after a review of timing and contacting systems for use in the primary side. Prime consideration has been the proper phasing of the instant of contact make and break with the sine-wave of the power supply, thus generally limiting possible exposure intervals to integral multiples of one cycle of power-line frequency, or, according to most recent developments in phasing control, to integral multiples of one-half cycle. Hence, in the electrical sense, minimum exposure duration with primary contacting is 1/120 second with 60-cycle power, though it has been assumed in the case of such half-cycle exposures that, due to the sine wave-shape of the voltage, the effective duration of the exposure is approximately 1/240 second. Therefore, contact making and breaking in the secondary side seemed to be essential in order to obtain exposures of 1/500 to

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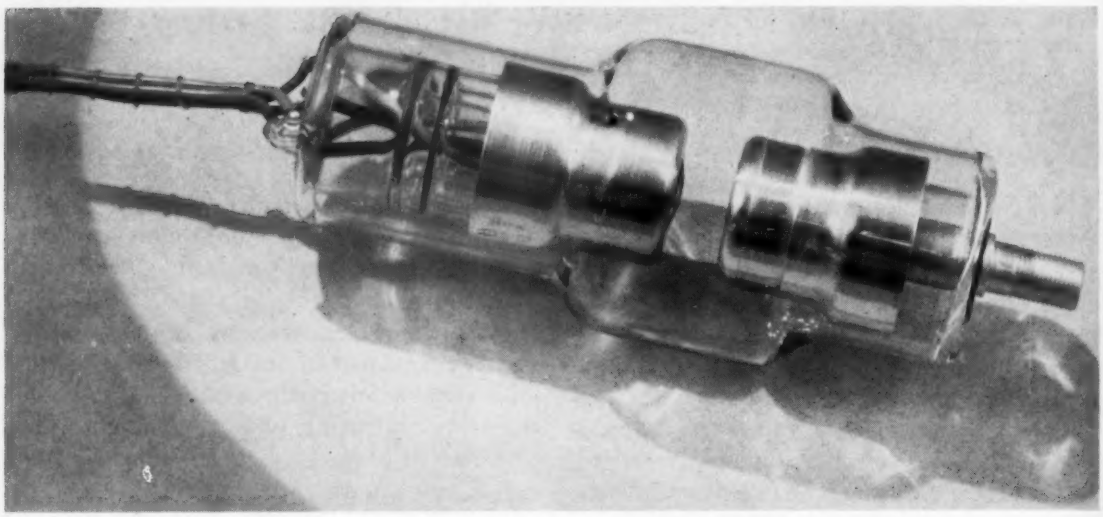

Fig. 1. Photograph of high voltage switching tetrode.

1/1000 second in duration.

Considering the voltages and time factors, it followed that the contact making and breaking device to be used in the high-tension circuit should be a controlled electron-flow vacuum tube rather than any form of mechanical switch. The conventional high-voltage valve tube that has been used for rectification in roentgen machines for many years is an example of an electronic high-tension switch. It only controls *direction* of electron flow, however, permitting electrons to flow freely in one direction and completely blocking flow in the reverse direction. For control of exposure duration, a switch is needed which will either block or permit free passage of electrons in the same direction, in accordance with the switching signal from a timer. Such action is, of course, the function of conventional triodes, as used in radio transmission, etc. Conventional triodes are not suitable for this application, however, partly because of inability to handle the very high voltages involved and because of control circuit characteristics required.

The past contains examples of attempts to combine the high-voltage capabilities of roentgen valve tubes with the grid-control feature of the triode to produce a high-voltage switching tube for control of roentgen exposures. Such tubes have achieved some degree of success in conjunction with certain rather elaborate and complicated varieties of apparatus designed specifically for cineroentgenography. For a device to be adapted to existing diagnostic equipment, to provide precisely timed exposures in the one to three millisecond range, low control-circuit voltage and power requirements and simple control circuitry are desirable. To this end, the switching tube and control circuit herein described have been developed.

The design of the switching tube itself was governed by a number of factors which were assumed to be essential or desirable at the outset, namely:

Roentgen-ray voltage: up to 125 kv.
Roentgen-ray current: at least 1,000 ma.
Exposure range: 1 to 5 milliseconds
Control grid voltage: not to exceed -300 volts
Control grid power: as low as possible
Anode voltage drop: not to exceed 1 kv.
Filament power: as low as possible

Evaluation of these requirements ultimately dictated that the tube should take the form of a tetrode rather than a triode. Tetrode circuitry permits a much higher *mu*, or amplification factor (needed for low cut-off grid voltage with high plate voltage), and at the same time requires much

lower grid driving power. A thoriated tungsten filament was employed to provide ample emission with a minimum of filament heating power. Figure 1 is a photograph of the tube. Intended for oil immersion, its over-all length is approximately eight inches. Its electrical characteristics are given in Table 1.

The circuit of this switching system, employed in conjunction with a conventional rectified generator, is shown schematically in Figure 2. The "filter condensers" are incorporated so as to eliminate the necessity for phasing with line voltage, and also to make the system essentially independent of generator capacity, line drop, etc. The "pulse transformer," of special design to transmit square pulses 1 to 5 milliseconds long without appreciable distortion, serves to isolate the control ciruit from the high-tension part of the system. The control grid bias and screen grid potentials are provided by an isolation transformer, with multiple secondaries, through selenium rectifiers with suitable filters. The same transformer supplies power to the filament. The filter condensers, the pulse transformer, and the switching tube with its grid-bias and filament power supply will be mounted in a common oil-filled enclosure, and interconnected with the conventional generator and roentgen tube by means of shockproof cables. An auxiliary high tension switch cuts the electronic switching system, including the condensers, in or out of the circuit at will.

TABLE I

CHARACTERISTICS OF HIGH VOLTAGE SWITCHING TETRODE

Hold-off voltage:	125 kv. max.
Inverse voltage:	125 kv. max.
Cut-off grid voltage:	−300 volts (for 125 kv. hold-off voltage)
Driving grid voltage:	+150 volts approx. (for 1,000 ma. anode current)
Control grid current:	100 ma. approx.
Screen grid voltage:	+800 volts
Screen grid current:	25 ma. approx.
Filament voltage:	6.5 volts
Filament current:	12.0 amperes approx.

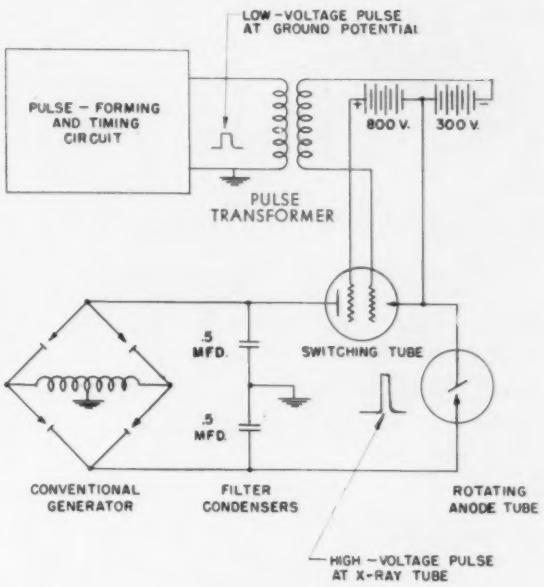

FIG. 2. Schematic diagram of electronic switching for ultra-short exposures.

The pulse-forming circuit, operating at low potential to ground and having to provide only relatively low-voltage and low-current pulses, becomes a relatively simple problem in electronic circuitry that can be handled in a number of ways. A simple circuit for exposures initiated under control of the angiocardiographic device, as used for the experiments herein described, is shown in Figure 3.

The form of voltage pulse which is applied to the roentgen tube is indicated by the oscillograms shown in Figure 4. These traces were photographed with the 'scope connected across the roentgen tube through a suitable capacitance voltage divider, and with approximately 80 kv. and 1,000 ma. load. Pulse lengths are 1 and 2 millisecond, respectively. It will be noted that voltage "droop" during the pulse corresponds very well with the calculated value of 4 kv. per millisecond, based on the capacitance of the filter condensers and the discharge rate.

Preliminary exploration was done to establish suitable roentgenographic technique factors for use with this system. Employing a Super Dynamax tube and a Westinghouse 500 ma. generator, films of satisfactory quality were made with a Fair-

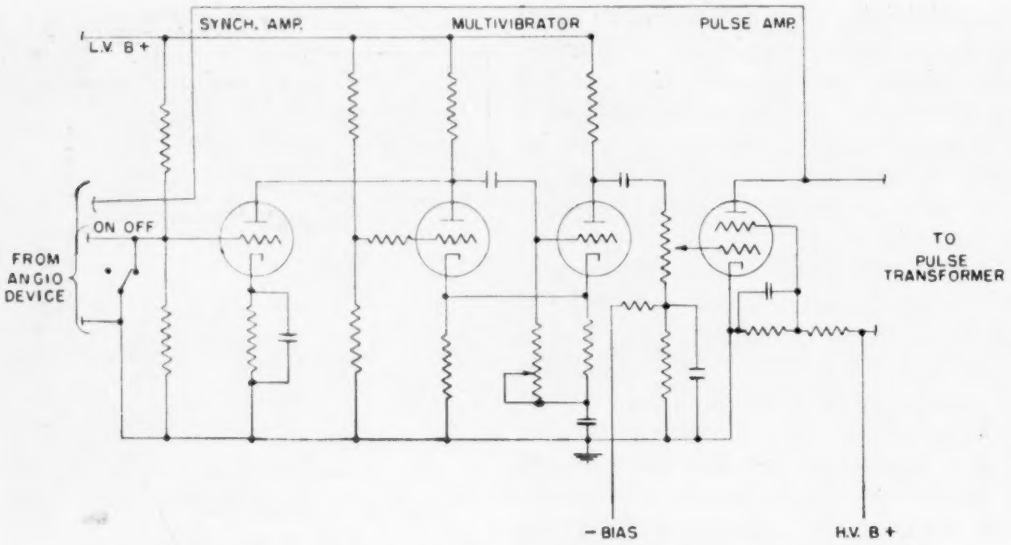

FIG. 3. Pulse-forming and timing circuit for control of high voltage switching tube.

child roll film magazine and an Automatic Seriograph cassette changer. Typical factors for an 11 cm. anteroposterior chest film were 92 kvp., 1,075 ma., 36 inch target film distance, and .001 second exposure duration. A 15 cm. lateral required 95 kvp., 1,075 ma., 36 inch target film distance, and .0015 second exposure time. Grids and high speed screens were employed. A number of actual angiocardiograms were made, and are discussed later herein.

The matter of a suitable roentgen tube for use with such exposure factors naturally arises. So far, all experiments have been carried out using a standard Super Dynamax rotating anode tube. These exposures, using square impulses of such short duration, represent radically different service conditions as compared with the standard conditions of usage, so that life estimates cannot be made based on previously acquired statistical data. Exhaustive life

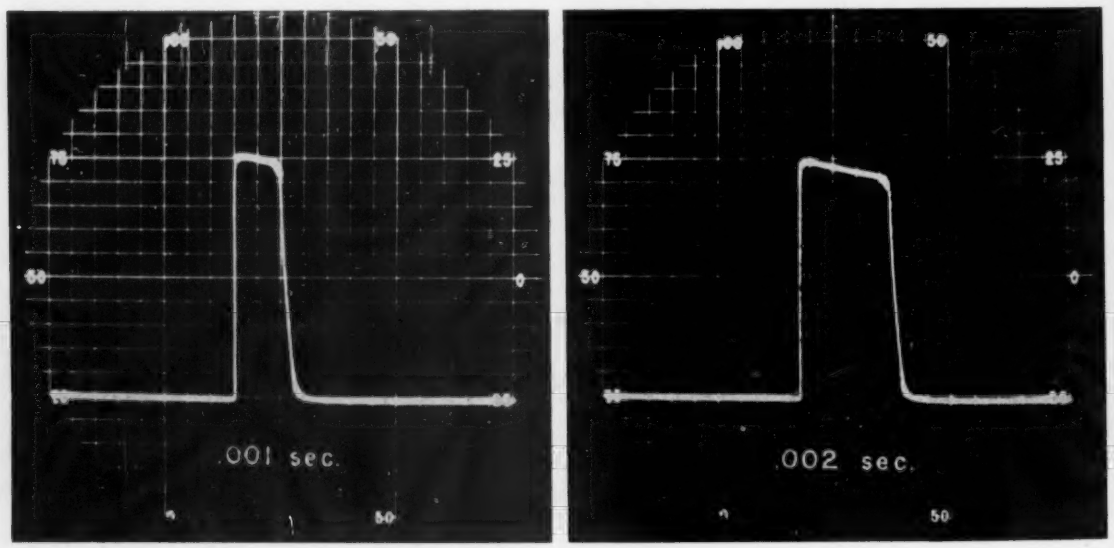

FIG. 4. Oscillogram of .001 second and .002 second voltage pulses.

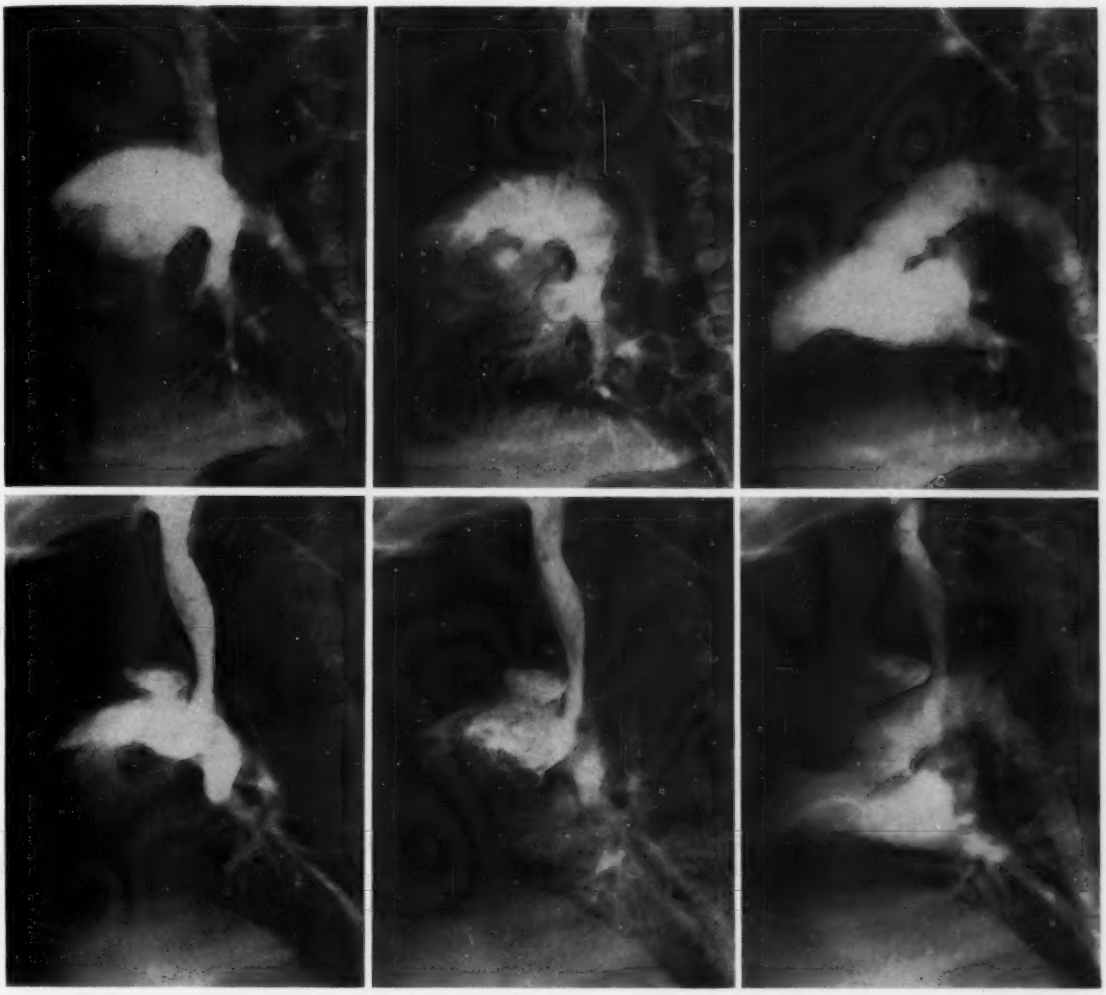

Fig. 5. *Effective Short Exposures in Angiocardiography.* Dog #5, two injections, 10 cc. 70 per cent urokon sodium. Upper sequence 1/10 second exposure; lower sequence 1 millisecond exposure. Short exposure studies are more detailed, show sharper borders of contrast agent, and turbulence. Aortic valves shown.

testing under the new conditions has not yet been accomplished, but the condition of the one tube used for a great deal of experimentation with the circuitry and for the clinical tests suggests that an acceptable life will be obtainable with the standard heavy-duty rotating anode tube. Of course, proper filament-boosting technique is necessary to conserve filament life at the high emission temperature required. In the long run, it may prove necessary to invoke some of the known approaches to increased instantaneous loading capacity, such as increased speed of rotation and larger target diameter.

DISCUSSION

During the early phases of development of this switching system, experimental angiocardiographic studies were done in order to evaluate the advantages of short exposures. Figure 5 affords comparison between two angiocardiographic sequences performed similarly on the same dog but with widely different exposure times (1/10 and 1/1000 second). Detail in short exposure films is far superior, and the information derived is considerably greater. Turbulence is shown, as are contributory jets of nonopaque blood entering areas

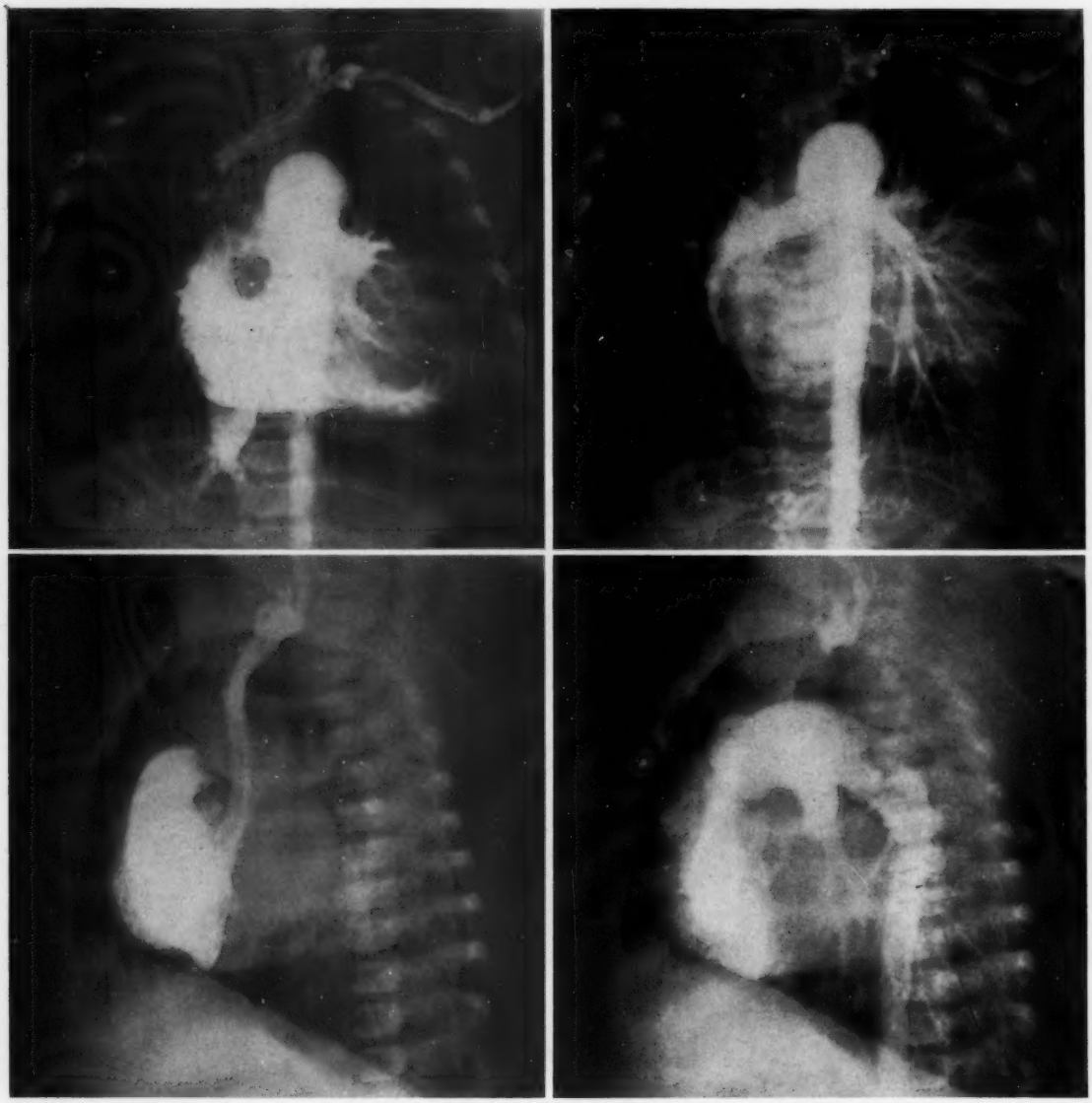

FIG. 6. *Angiocardiography with Ultra Short Exposures.* Technical factors: 92 kvp., 1,075 ma., 1/1,000 second, 40 inches target film distance, anteroposterior; 95 kvp., 1,075 ma., 1/1,000 second, 40 inches target film distance, lateral. Note flow pattern in superior vena cava and atrial and ventricular trabeculae. Lateral right heart film shows pulmonary valves clearly, as did other films from this sequence. Detail superior to studies with conventional exposure times. Diagnosis: Fetal coarctation of aorta.

visualized by contrast substance. Anatomical structures previously unrecognized are often shown with clarity. The encouragement offered by initial experiments led to further development of the apparatus and its application at the University of Oregon Medical School. The resultant improvement in clinical angiocardiography is illustrated by Figures 6 and 7.

To be maximally useful, any roentgenogram and especially an angiocardiogram (where movement is of considerable importance) must show optimal detail. In addition to cardiovascular movement, the factors of screen contact and mechanical stability of the recording device have an important role in the achievement of detail. This has definite bearing on the design of

film changing devices for angiocardiography. The more rapid the rate or frequency of exposures, the greater will be the problems presented by these factors.

Current technical progress in angiocardiography has been directed toward increasing the number of exposures per second. This has resulted in a more complete registration of the cardiovascular structures traversed by the bolus of injected contrast substance. The improvement is due, in part, to the fact that certain structures exhibit little or no movement during a portion of each cardiac cycle. Thus, while a leaflet of the pulmonary valve might be moving rapidly during early ventricular systole, it is relatively stationary during diastole. An angiocardiographic series exposed at twelve films per second would include views made during both of these phases and, therefore, could be expected to show the pulmonary valves where exposure and valve immobility coincided. Since during angiocardiography satisfactory opacification exists in the region of any of the valves for a period of two seconds or more, it should be feasible to conduct diagnostic studies with far fewer exposures per second, thus promoting film economy and minimizing radiation hazard. Adequately short exposures are essential, however. These must be short enough that the image of the pulmonary valve can be recorded at the moment of maximum movement. Four such exposures per second may prove to be the diagnostic equivalent of current twelve per second techniques. Furthermore, by reducing the mechanical problems incidental to high exposure rates (poor screen contact, vibration, etc.), it should be possible to improve recording detail. The optimal exposure rate is that which will produce the desired information and is certainly not the maximum possible rate. This optimal rate cannot be determined until measures have been taken to produce high image-definition.

A contribution of short exposure techniques to angiocardiography will probably be the reduction in volume of contrast agent necessary for a given study. The sharper definition between contrasted and noncontrasted areas allows reduction of dosage and thus promises to make angiocardiography safer (while ar the same time its diagnostic accuracy is enhanced). Certain angiocardiographic problems can be handled equally well with short or with ordinary length exposures. In coarctation of the aorta, the major structural variation in the relatively immobile aortic arch can be demonstrated reasonably well with exposures as long as 1/30 second. Clearly, however, conventional exposures are too long where intravascular turbulence and rapid movement are under consideration.

The short exposure technique presented here is adaptable to conventional diagnostic roentgen apparatus. It should prove to be of value in routine roentgenography where involuntary patient movement (fre-

Fig. 7. *Angiocardiography with Ultra Short Exposures.* This lateral film, exposure duration 1.5 milliseconds, was part of a sequence demonstrating tetralogy of Fallot with subvalvular stenosis. Besides showing turbulent filling of the right atrium, it demonstrates a small jet of contrast agent entering the left atrium—indicating the additional presence of an interatrial defect. Without the detail afforded by the short exposure, the finding would probably have been missed (since the shunt was small and showed only on this film).

quently a product of the disease under study) represents a threat to roentgenographic detail. Pediatric roentgenography represents a further application. Other uses will probably become apparent. By varying the characteristics of the control circuit, it is possible to vary the length of exposures. It is possible that by means of the switching system, there may be achieved control of beam quality as well as exposure duration.

A possible extension of the grid control principle would be to incorporate the grid in the diagnostic tube itself. Diagnostic roentgen tubes incorporating a grid have been constructed by various workers in the past. None met with great success and no such tube is known to be commercially available. Certain objections exist to placing the grid within the diagnostic tube. The electron beam must necessarily be altered by an electrically charged structure interposed between cathode and anode. This effect may prove to vary with changing tube temperatures. Furthermore, the expected life of a switch tube is considerably greater than that of a diagnostic tube, and it would be false economy to replace two elements when only one had failed. These objections are admittedly hypothetical and should not serve as deterrent to further investigation of this aspect of the problem.

SUMMARY

A method for the achievement of one to five millisecond exposures for clinical roentgenography has been described. This has consisted of a high voltage tetrode operated in series with the diagnostic roentgen tube. The tube and its associated circuitry have been described as well as principles of operation.

The application of millisecond exposure techniques to angiocardiography has been illustrated and discussed in particular relation to detail, optimal exposure frequency, and increased diagnostic yield. It is hoped this preliminary report will encourage further work along the line suggested here.

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NOTE: The switch tube was designed and constructed at Machlett Laboratories, Incorporated. Urokon sodium used in the angiocardiograms was supplied by the Mallinckrodt Chemical Works. The manufacturer's loan of the Automatic Seriograph is gratefully acknowledged.

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CLINICAL STATIONARY FIELD THERAPY WITH A COBALT-60 UNIT

PART I

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THE concept of anatomical fields was originated by Coutard who integrated it with the principle of fractionation and the clinical radiobiological behavior of tumors. From this concept evolved modern radiotherapy. This developing discipline shapes physical quantitative techniques to the natural history of clinical entities.

Previously, large portals had been used, even in cross-firing techniques. Hence, tumor-bearing areas were but crudely encompassed. The sterilization of tumors was occasional; reactions were severe and often fatal complications followed, caused by high doses of radiation delivered to large areas of skin or to large volumes of tissue. Coutard carefully defined the areas to be irradiated, and observed the effects of fractionation on tumors and mucous membranes. Hence, he was able to deliver lethal tumor doses and obtain systematic cures in deep-seated squamous cell carcinomas, using external irradiation alone. His brilliant clinical investigations established that not only the histopathology, but also the site of origin of tumors, their ways of contiguous extensions and their paths of spread along the lymphatics and/or the blood vessels, determined the planning of treatment and the fate of the patient.

Through the years a wealth of clinical observations has accumulated. This is now integrated into a body of knowledge which is the basis for both the surgical and radiotherapeutic management of cancers. This clinical approach has been a major contribution of radiotherapy to the treatment of cancer patients, for it reaches beyond the strict use of radiation techniques. Surgery is confronted with the same problem. More radical and therefore more effective means of removing *en bloc* the primary tumor and its regional metastases have led to the shaping of surgical techniques to the behavior of cancers. This competitive increasing effectiveness of both radiation and surgery has been a considerable incentive in our study and understanding of the natural history of cancers, which is an inherent trait to which any means of control has to be fitted.

Radiotherapeutic treatments are planned to deliver a lethal dose to the area which covers adequately, but not too generously, the tumor and its probable lymphatic or contiguous extensions. For instance, tumors of the paranasal sinuses do not frequently metastasize to the neck nodes, and the radiotherapeutic management, either primary or postoperatively, is only concerned with the irradiation of the paranasal sinuses area. Tumors of the lateral border of the tongue can be cured by interstitial gamma-ray therapy in a high percentage of cases, but the lymph nodes of the neck, if they are to be treated, are best handled by radical neck dissection. In contradistinction, anaplastic tumors of the base of the tongue, tonsillar fossa, and nasopharynx are not managed correctly radiotherapeutically if the primary and the lymphatics of the neck, including the retropharyngeal lymphatics, the spinal accessory chain, and the posterior cervical triangle nodes, are not covered in their entirety in continuity with the primary.

In addition to the use of fractionation and anatomical fields, another contribution of the Curie Foundation is the observation that all parts of a tumor do not require

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the same dose to be sterilized. The classical example are tumors of the tonsillar fossa which, if advanced, involve upward the soft palate, posteriorly the lateral pharyngeal wall, and downward the glossopalatine sulcus going into the base of the tongue. It is common experience that the delivery of a tumor dose producing the disappearance of all the extensions including the primary in the tonsillar fossa will be followed by the persistence of induration in the base of the tongue, which will be the site of actively growing cancer. Cures are obtained only by additional radiation to the base of the tongue, for instance by means of an interstitial implant.

Accumulated clinical observations have given circumstantial evidence that young peripheral extensions and scattered microscopic nests of cells are more radiosensitive than big masses. This is in agreement with our knowledge of the relative effectiveness of the direct and indirect action of radiation on tumor cells, the latter being a function of oxygenation. The management of metastatic nodes in the neck, suitable for external irradiation (for instance, nodes from nasopharynx, tonsillar fossa, base of tongue, or extrinsic larynx tumors) is a classical example. After the whole neck has been irradiated to the maximum tolerated dose, small, usually tangential, fields are individually aimed at remaining palpable nodes, avoiding the spinal cord and the mucous membranes of the larynx and pharynx. In this way, permanent sterilization of the nodes can be obtained. Otherwise, reactivation of the residual palpable mass will occur. Uncontroversial cures of metastatic neck nodes by external irradiation alone have been reported by this method.

Narrowing of the fields at the end of treatment to carry areas of persistent disease to higher doses is an essential practice of clinical radiotherapy. It is one of the bases for success in some tumors of the head and neck and breast. It is in conflict with the concept that a homogeneous dose should be given to the entire tumor-bearing area. This latter concept is theoretical, whereas the differential response is a clinical fact which has been, and is verified by clinical experience. It should be stated that this concept of inhomogeneity of tumor dose is not the same as the theory used in grid therapy.

In conclusion, shaping is clearly not simply a geometrical problem involving a three-dimensional anatomy. It should be conceived also as a function both of time and the differential response to radiation of the various parts of the same tumor. This response of the tumor and the reactions of the supporting structures vary widely among individuals. Therefore, any planning is only tentative, based on average response. As the treatment progresses, modifications have to be made to fit the evolution of the individual case.

Irrespective of any concept one may have about radiotherapeutic techniques, the vital prerequisite is anatomical accuracy. Cancer cells are not sterilized by volume distributions adequate on the work sheet, but by the radiation actually delivered to those cells. The more elaborate the technique, and the more one departs from simple anatomical fields, the more hazardous becomes the sure coverage of the tumor with a sufficient margin. Tumors rarely grow in perfect spheres or cylinders or in simple geometrical patterns. Even cancers of the esophagus are only seemingly ideal cases. These tumors are actually tortuous along a general central axis of the tumor. Metastases in the mediastinal lymph nodes, almost always present, can only be irradiated if one wants to be curative, by two anteroposterior opposing fields. Tumors of the urinary bladder can be well encompassed by spheres produced by rotational techniques. However, this coverage is only adequate for a fraction of the existent disease, for tumors of the urinary bladder invading the muscularis mucosae almost always have metastasized to the pelvic lymphatics. This involvement determines the fate of the patient.

These clinical facts relate to the nature

Fig. 1*A*. Tumor probably arising on the left retromolar trigone and invading very deeply the anterior faucial pillar, part of the buccal mucosa, and the soft palate. The tumor measures about 5 cm. in its greatest diameter and is grossly ulcerated with edges about 2.5 cm. in thickness, infiltrating deeply into the buccal mucosa at the junction of the ascending ramus. The glossopalatine sulcus is slightly involved and there is no palpable involvement in the base of the tongue. There are three palpable nodes measuring from 2 to 3 cm. in diameter located in the left submandibular and carotid regions. The histopathological diagnosis was squamous cell carcinoma, Grade 2, and an aspiration biopsy from one node was also positive.

In view of the marked laterality of the disease, the treatment was planned with a homolateral portal. A given dose of 6,000 r in four weeks delivered a tumor dose of 6,000 r to the lymph nodes, approximately 5,900 r to the tumor in the buccal mucosa, and 5,000 r at the level of the faucial pillar. At that time there was still marked induration and deep infiltration of the buccal mucosa and anterior faucial pillar. A small field was then used adding a given dose of 1,700 r, delivering a total minimum tumor dose of 6,000 r on the faucial pillar, and a maximum of 7,500 r in the buccal mucosa in five weeks. This additional treatment produced marked softening of the induration. The photograph was taken on the last day of treatment. There was about a 50 per cent regression of the size of the neck nodes. They were not covered by the small narrowed field because, in view of the keratinizing nature of the squamous cell carcinoma, a radical neck dissection was contemplated and scheduled for four weeks after the completion of treatment. A skin dose of 3,675 r was given during the treatment to the supraclavicular region.

of cancers, and do not depend upon wavelength. The relative radiosensitivity of the various parts of a tumor is the same, irrespective of the energy level, with perhaps the exception of areas of bone invasion. Consequently, the development of radiotherapeutic equipment resulting in greater depth dose, lesser skin reaction, lesser differential bone absorption, lesser integral dose, and therefore a somewhat lesser systemic reaction, would be useless if a true anatomical and clinical radiobiological shaping were not possible.

PROCEDURES

The physical techniques are described in Part II. The adaptability to produce volume distributions, taking into consideration the anatomical location of tumors and their clinical behavior, is made possible by (1) utilization of anatomical fields; (2) differential skin doses to portals in multiple field technique, and (3) change of field arrangement, and/or reduction of the size of the portals as the treatment progresses in order to deliver higher doses to the more resistant parts of the tumor.

(1) *Anatomical Fields.* An anatomical field is freely drawn on the skin covering the tumor-bearing area. If only squares, rectangles, or circles are available, unnecessarily large fields have to be used, or large corner areas have to be included where there is no tumor. For instance, patients with tumors of the tonsillar fossa are best treated by an odd-shaped field which includes the tonsillar area, the lateral pharyngeal wall and the lymph nodes of the carotid region and upper jugular and spinal accessory chain (Fig. 1*A*). Practically all portals covering lymph node areas are somewhat trapezoidal in shape, and it is from this simple but essential concept that the light localizer originated (Fig. 1 and 2). In the treatment of patients with head and

FIG. 1*B*. Patient with two lesions. One originated on the base of the faucial pillar and tonsillar fossa, involving the glossopalatine sulcus and tongue; the other was located on the left alveolar ridge, starting almost from the midline anteriorly, and reaching the retromolar trigone posteriorly. As there was practically no free area between the two seemingly separate squamous cell carcinomas, they were treated in continuity. On the homolateral side the portal was drawn to fit the shape of the lesion. A smaller portal on the contralateral side was used, covering the base of the tongue and the tonsillar region. This was necessary as the tumor was deeper at that level. Note that the patient is treated with a cork in the mouth to which a wooden tongue depressor is fastened in order to get the anterior aspect of the tongue out of the beam.

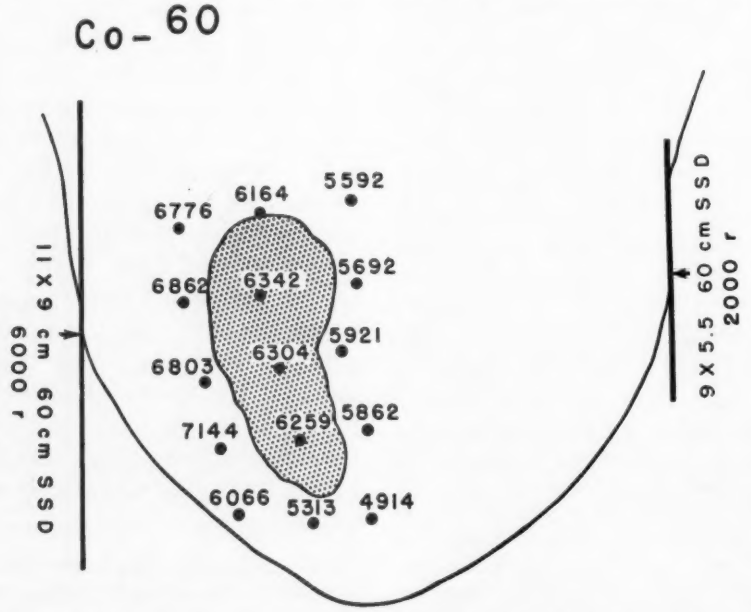


FIG. 1*C*. Volume distribution of Figure 1*B*. Not only is the contralateral portal smaller, covering only the base of tongue, but the given dose is less.

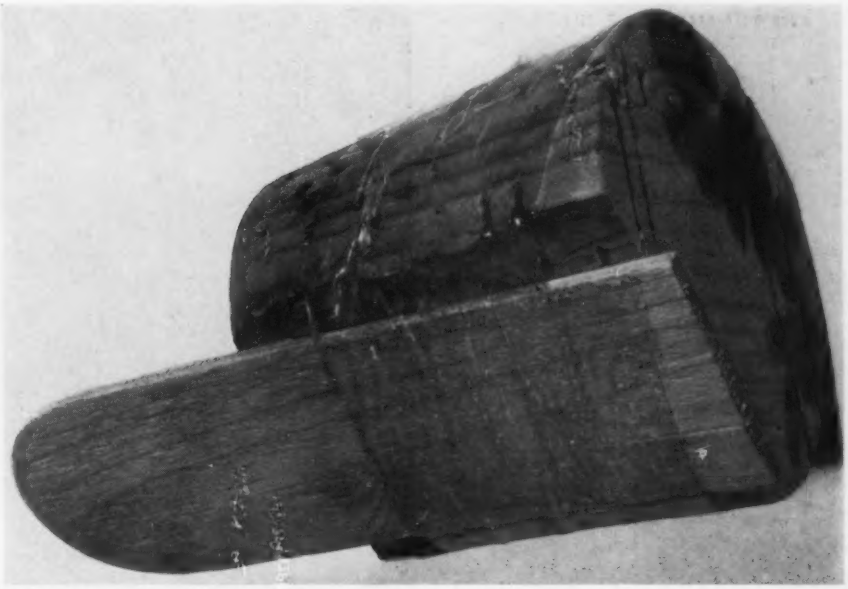


Fig. 1*D*. Photograph of cork with fastened tongue depressor. The practice of avoiding irradiation of the lower aspect of the oral cavity, including the tongue, in tumors of the upper alveolar ridge, paranasal sinuses and nasopharynx, and conversely avoiding irradiation of the palate in tumors of the tongue, floor of the mouth, and lower alveolar ridge, prevents a sharp mucositis on the uninvolved half of the oral cavity, and the treatment is better tolerated.

neck tumors, the sparing of any portion of the mucous membranes or vital structures, such as the spinal cord or the arytenoids, may mean the difference between tolerated reactions and severe, or even fatal complications. The management of neck nodes is impossible with small glancing fields, without an accurately adjustable light localizer.

(2) *Differential Skin Doses in Multiple Field Technique.* The practice of not delivering the same skin dose, or in supervoltage therapy the same given dose, to all portals in multiple field technique may be used with advantage to achieve several purposes. It shifts the maximum dose to areas which ought to be treated more heavily, at times eliminates hot spots resulting from the geometrical arrangement of the fields, and helps to encompass the anatomical distribution of the disease more thoroughly. For instance, in the treatment of patients with tumors of the tonsil by two opposing portals, a proportion of two to one, or two to one and a half, in favor of the homolateral portal shifts the maximum to the size involved including the carotid area (Fig. 1*C*). In tumors of the nasopharynx, equal given doses to the two lateral and the two anterior portals result in an unnecessarily hot spot on the nasal septum. In addition, because of the extreme frequency of involvement of the retropharyngeal lymphatics, in particular the retropharyngeal nodes, it is of advantage to make maximum use of two opposing lateral portals, thereby producing a coverage to a higher tumor dose of all the retropharyngeal lymphatics (Fig. 2*A*). In a three-field arrangment used for cancer of the esophagus or retroperitoneal lymph nodes, higher doses to the two posterior oblique fields prevent the anterior shift of the maximum tissue dose.

(3) *Change in Size and Arrangement of Portals toward the End of Treatment.* This is perhaps one of the most important practical consequences which has come from the concept that the site of origin of the tumor and/or certain extensions are more radioresistant (Fig. *1A*). A minimum tumor dose is delivered to the whole tumor-

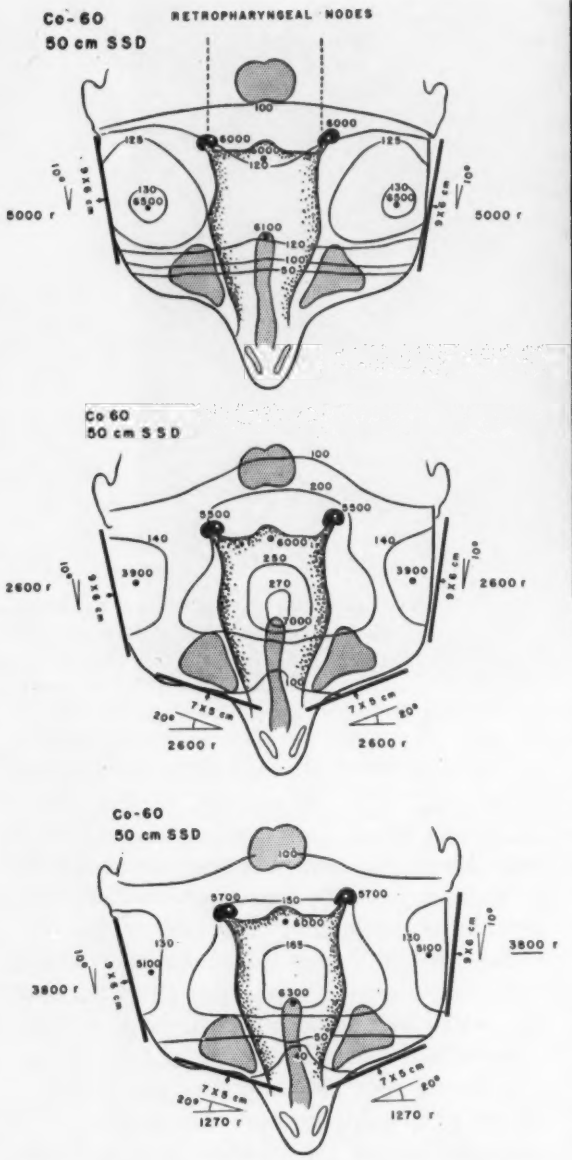


FIG. 2*A*. Comparison of three patterns using the contour of patient in Figure 2*B*. In the upper pattern, two lateral fields tilted back 10° are used. The volume distribution is very satisfactory concerning the retropharyngeal lymphatics but the dose to the temperomandibular joint, muscles, in particular the masseter muscle, and subcutaneous tissues, is high, and the possibility of late fibrosis with locked jaw is great. In the middle pattern the same given dose is delivered to the four fields, and in the lower pattern a greater given dose is delivered to the lateral fields supplemented by anterior portals to bring up the total tumor dose to 6,000 r. The lower pattern is better for the following reasons: (1) the hot spot on the nasal septum is less on a smaller area; (2) the retropharyngeal lymphatics are better covered. The dose to the muscles, temperomandibular joint and subcutaneous tissue is appreciably less than in the two opposing portal pattern, lessening the possibility of crippling fibrosis. These differential given doses to the four fields are used with advantage on the 250 kv. equipment.

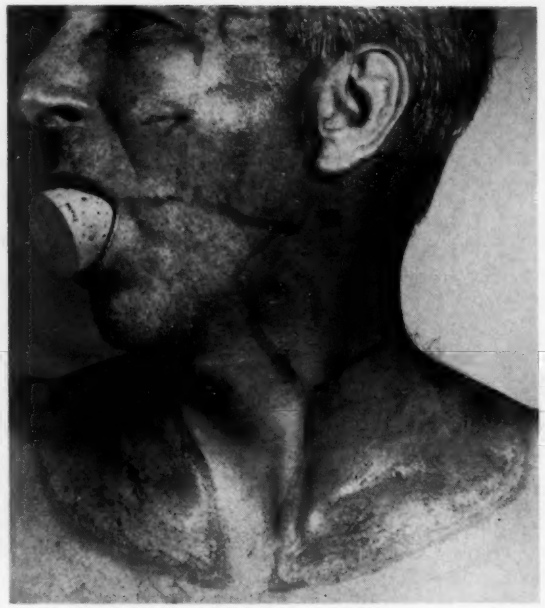
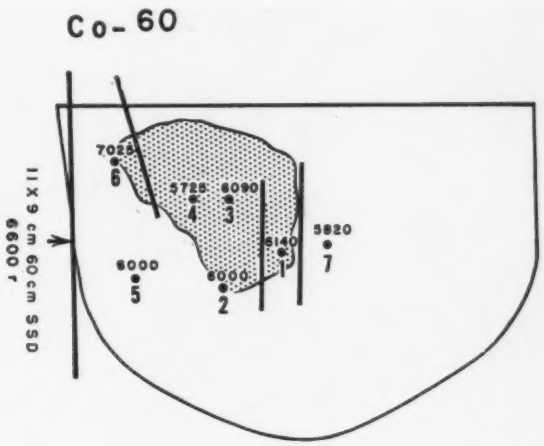


FIG. 2*B*. Anaplastic squamous cell carcinoma of the nasopharynx with multiple bilateral palpable nodes in the spinal accessory chain starting at the level of the mastoid tip. This case was treated with 250 kv. and the photograph was taken at the end of treatment.

For irradiation of the lateral portals the patient's head is lateral, and the beam is tilted 10° to the back to assume coverage of the retropharyngeal lymphatics which are in the same frontal plane as the auditory canal. For treatment of the anterior portals, the patient is supine with the outer canthus-tragus line vertical. The central axis of the beam is aimed at the roof of the nasopharynx. A cork is placed in the patient's mouth to spare the dorsum of the tongue.

The upper cervical fields are treated as two opposing laterals up to 4,000 r which is also the dose to the spinal cord. Afterwards small anterior and posterior tangential fields are used. The supraclavicular fields are treated with the patient in supine position, the head oblique, the beam tilted slightly downward and medially in order to cover adequately the lymph node areas located just above the clavicle.



POINT	1	2	3	4	5	6	7
THREE PLANE Ra. IMPLANT 25 Hrs.	2140 r	1400 r	1490 r	825 r	500 r	1325 r	2100 r
Co^{60} 11 X 9 cm. FIELD 6600 r 4 WEEKS	4000 r	4600 r	4600 r	4900 r	5500 r	5700 r	3720 r
TOTAL (5 WEEKS)	6140 r	6000 r	6090 r	5725 r	6000 r	7025 r	5820 r

Fig. 3. Extremely advanced tumor, probably originating in the left tonsillar fossa which is replaced by a deep crater, also occupying the entirety of the lateral pharyngeal wall. The glossopalatine sulcus and more than half of the tongue are involved. The involvement of the tongue reaches almost to the tip and crosses the midline on the base of the tongue. The palate is only slightly involved. A node measuring about 3 cm. in diameter is present behind the left angle of the jaw, and another node measuring 2.5 cm. in diameter is palpable under the sternocleidomastoid muscle at the midjugular level. The histopathologic diagnosis is squamous cell carcinoma, Grade 2.

A tumor dose of 6,000 r was delivered in five weeks by a combination of a homolateral field and a modified tongue-pterygoid implant. The neck nodes were included in the field. Seven weeks after the completion of treatment there was still located in the base of the tongue and extending anteriorly a stony hard induration measuring about 3 cm. in diameter. A three-dimensional gold pellet implant was thought to be the treatment of choice to provide irradiation without traumatizing the mucous membrane of the base of the tongue. In this manner there was less chance of infection and necrosis, an important consideration in view of the already heavy previous irradiation. The gold pellet implant was approximately a cylindrical volume of 9.24 cc. with a calculated dose of 7,950 r. Ten days following the implantation a uniform pseudomembranous mucositis was present over the base of the tongue, the soft palate, the glossopalatine sulcus, and the faucial pillars. This uniform reaction shows that a volume implant had truly been performed. The node located in the midjugular level required an additional 3,000 r delivered on a 5 by 4 cm. tangential field before it disappeared. Eventually the tongue got softer, and six months later there was no evidence of disease. The patient is comfortable and able to work.

A combination of radiotherapeutic procedures decided upon and performed as the disease evolved, requiring as much as approximately 13,000 to 14,000 gamma roentgens in some areas, has controlled the disease. The volume which received such a high dose was only 10 cc. and was located well within the muscle of the tongue which has a very high resistance to radiation damage.

bearing area and then the treatment is continued using smaller fields over the site of origin, or over areas in which there is still palpable or visible disease, or where disease has disappeared last. The delivery of extra radiation to residual palpable masses is at times done best by interstitial gamma-ray therapy. A classical example

FIG. 4. Edentulous patient with multiple scattered leukoplakic areas throughout the whole oral cavity. In addition, there were four areas of malignant degeneration proven by biopsy. These areas were: (1) posterior aspect of the left floor of the mouth; (2) floor of the mouth to the right of the frenulum; (3) right lateral border of the tongue, and (4) upper right gum at the site of the first molar. The whole of the oral cavity was irradiated by two opposing fields, with additional therapy to the areas of proven malignant degeneration. The four areas were first treated with the Chaoul (60 kv.) machine, delivering 1,500 r in three days and immediately afterwards the treatment was started on the Cobalt-60 unit. A tumor dose of 4,500 r in four weeks was given with the Cobalt-60 unit, making a total dose of 6,000 r in four and a half weeks to the areas of malignant disease. A severe mucositis appeared on the tenth to twelfth day and had already markedly regressed at the end of treatment. The photograph, taken on the last day of treatment, shows the portals and the mucositis on the under surface of the tongue, sparing the lips, which were free from leukoplakia. Tungsten slabs had been used to get a sharp beam at this level, as it was important to lessen discomfort. Despite the high dose delivered to the whole mucous membrane of the oral cavity the patient lost only 1 pound in weight during the treatment, which lasted four and a half weeks. This is given as an example of the clinical usefulness of a sharp beam and of a flexibility of equipment, adaptable to clinical planning. At the completion of treatment all areas of squamous cell carcinoma and all leukoplakia had disappeared.

is the infiltration in the base of the tongue from tonsillar tumors. A gold seed implant[1] or radium needle implant is, at times, the best means of delivering the necessary extra tumor dose (Fig. 3). This practice is the key to success in many primary head and neck tumors, in metastatic neck nodes, and in breast tumors.

CLINICAL SHAPING

The clinical adaptation of a telecobalt-60 beam to some of the commonly encountered radiotherapeutic problems will be discussed by anatomical areas. The discussion does not include the tumor dose-time factor. Only large series of cases followed over years will determine the optimal relationship at this energy level. The figures mentioned in the illustrated cases are for the sake of completeness of the record. Depending upon a rapidly evolving experience, they might be different in the future for similar cases.

Head and Neck.

Nasopharynx: A careful anatomical plan of irradiation of the nasopharyngeal primary in continuity with the retropharyngeal lymphatics and the lymphatics of both sides of the neck results in a high percentage of local control for either lymphoepitheliomas or anaplastic squamous cell carcinomas. Frequently, the patient will die from distant metastases without evidence of disease above the clavicle.

Due to the skin sparing effect, one would be tempted to use only lateral portals with the Cobalt-60 beam. A tumor dose of 6,000 r in four weeks can be given with only a faint erythema of the skin. However, this pattern produces a heavily irradiated slab of tissue with the maximum dose at the level of the muscles (primarily the masseter), the temperomandibular joint, and the subcutaneous tissues (Fig. 2*A*). Great caution should be exercised, as years later considerable fibrosis might develop, producing disabling trismus. It is therefore wiser to keep the classical four field arrangement, giving a greater dose to the lateral portals than to the anterior ones, as it does produce a better volume distribution. Treatment of the lymph node areas should follow the same clinical lines of thought as with conventional 250 kv. therapy (Fig. 2*B*). One should be careful not to carry the dosage too high to the upper cervical fields, as long as they are opposing lateral, in view of the radiation delivered to the spinal cord, which cannot be avoided, as the spinal accessory chain must be included. Small tangential portals must be used at the end of treatment.

Paranasal Sinuses: Malignant tumors of the paranasal sinuses and nasal contents yield very unsatisfactory results to any modality of attack. Primary radiotherapeutic treatment, either by intracavitary radium or external irradiation, is rarely successful, due to infection, necrosis, and consequently reduced response. This is because these tumors grow in closed spaces and invade bone early. There is no way to avoid infection even with generous use of antibiotics. These circumstances remain the same irrespective of the voltage. The availability of a Cobalt-60 beam has not changed the policy of our institution to employ a radical surgical procedure, even if the tumor is obviously not surgically resectable in its entirety. Typical operations include radical antrectomy, resection of the nasal contents, ethmoid and sphenoid sinuses on the involved side, and if the floor of the orbit is involved, exenteration of the orbit. Postoperative radiation therapy is given to all cases with the exception of the low grade adenocarcinomas when there is no definite proof of residual disease. The use of preoperative laminagrams, in addition to conventional films, and careful study of the surgical specimens help to

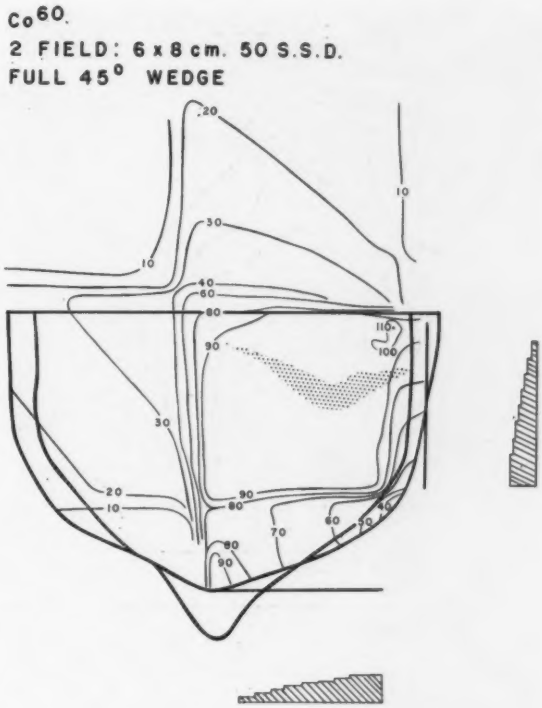


FIG. 5*A*. Volume distribution produced by two fields at right angles for irradiation of paranasal sinuses. The full 45° wedge arrangement gives an ideal volume distribution if one wants to deliver a homogeneous dose to the whole of the maxillary antrum, anterior aspect of the pterygoid fossa and homolateral ethmoid and sphenoid sinuses. This pattern is also best for postoperative irradiation if there is not clearance on the anterior aspect of the surgical defect.

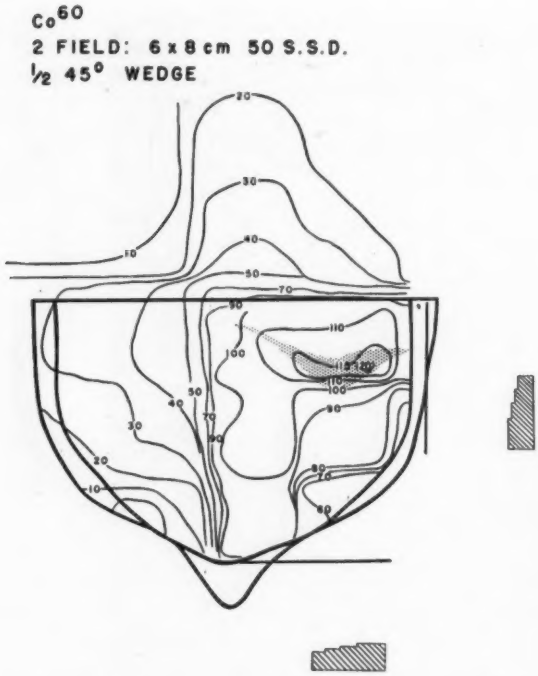


Fig. 5*B*. In the postoperative treatment of patients with maxillary or ethmoid sinus tumors when a radical antrectomy and a radical dissection of the nasal content and ethmoid cells and sphenoid have been performed, the areas of likelihood of recurrence are on the pterygoid wall which forms the posterior wall of the maxillary antrum, and in the ethmoid and sphenoid sinus areas where the dissection is made by scraping. Careful study of all pieces of the surgical specimen is of help to determine what areas are likely to be involved. If the anterior aspect of the surgical defect shows a safe margin of resection, arrangement of two fields at right angles with a half-wedge gives an ideal distribution to deliver the maximum dose to the posterior wall of the maxillary antrum, and the ethmoid sinus area.

determine the extent of the lesion and the evidence or great likelihood of residual disease around the surgical defect. For obvious anatomical reasons, the two weakest areas of the surgical procedure are on the posterior wall of the maxillary antrum, *i.e.*, the wall of the pterygoid fossa, which of course cannot be removed, and around the cavity surrounding the ethmoid and sphenoid cells where the dissection has been made by scraping. If the laminagraphic study shows no evidence of involvement of the anterolateral aspect of the maxillary antrum and the pathologic specimens indicate a clear margin in that area of the surgical defect, a two field arrangement at 90°, with a half wedge filter gives an ideal volume distribution. This produces an L-shaped form of the maximum dose over the sphenoid and ethmoid areas and the wall of the pterygoid fossa (Fig. 5*B*). If there is proven residual disease or even no assurance of surgical clearance anywhere around the surgical defect, the same 90° two field arrangement,

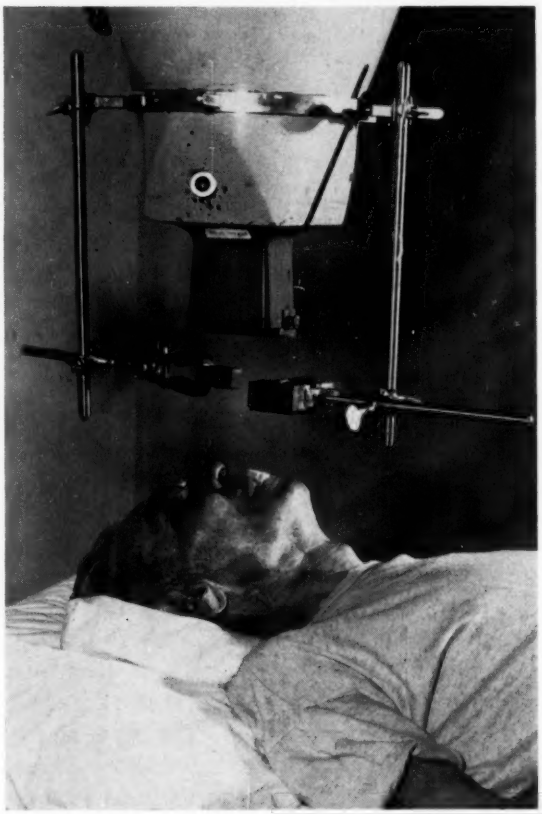


Fig. 5*C*. Patient under actual treatment condition with pattern of Figure 5*B*. A positive biopsy after operation had been obtained on the posterior wall of the surgical defect. One sees the attachment of the wedge filter to the cone. A cork (with wooden tongue depressor) is placed in the mouth of the patient to avoid irradiation of the tongue, and tungsten slabs are used to obtain a sharp cut-off of the beam and screening of the penumbra on the lower aspect of the field. A narrow tungsten slab shields the eye which has not been exenterated. The effect on the penumbra and on the screening of the eye is seen in Figure 6*A*, Part II.

but with a wedge filter over the whole width of the portals, gives the best volume distribution (Fig. 5*A*).

Tonsils: In tumors of the tonsillar fossa, which are localized to the original site, a homolateral field enables one to deliver an adequate dose at the level of the tonsillar fossa (80–90 per cent of the given dose) with decreasing doses to the glossopalatine sulcus, base of tongue, soft palate and posterior pharyngeal wall lymphatics, areas where microscopic spread is likely to be present. A method of treatment planned to deliver a small volume high dose to the tonsillar fossa alone results in a high incidence of recurrences. This is because of the tendency of anaplastic tonsillar tumors to spread early across the base of the tongue and the posterior pharyngeal wall lymphatics. The tissue dose to the midline is still about 70 per cent of the given dose and can be lethal for microscopic extensions which are more radiosensitive. The carotid and upper jugular chain must be included in the portal covering the primary. If the tumor is anaplastic, the lower jugular chain lymphatics ought to be irradiated. If the tumor is a keratinizing squamous cell carcinoma, one can be satisfied with irradiation of the upper neck lymphatics, leaving open the possibility of a radical neck dissection if indicated later.

More advanced tumors of the tonsil will invade grossly the soft palate upward and the base of the tongue downward. Then a contralateral portal is indicated, to increase the dose to the midline. However, the given dose to the homolateral portal should always be somewhat greater and the proportion is determined to achieve the maximum dose in the involved side (Fig. 1*B*). In the weeks following the completion of the external irradiation, if there is still residual infiltration in the base of the tongue, interstitial gamma-ray therapy, either in the form of radium needle implant or gold seed implant[1] ought to be performed to sterilize the more radioresistant disease in the muscle of the tongue (Fig. 3).

Fig. 5*D*. Four years previously, the patient had a lesion just anterior to the left ear and was treated by roentgen irradiation. Five months prior to admission he noticed a swelling in the tail of the left parotid. On examination there was a slightly movable mass measuring 4 cm. in diameter in the tail of the left parotid, and in addition there was a 1 cm. palpable node in the mid-portion of the posterior cervical chain. A total parotidectomy with left radical neck dissection was performed on June 23, 1953, with this pathological report: "Multiple foci of metastatic squamous cell carcinoma in lymphoid nodules within the parotid gland and within the parotid gland substance itself."

Six months after the parotidectomy there was complete recovery of the function of the facial nerve. On September 8, 1954, the patient's examination showed a return of the facial paralysis and several subcutaneous nodules just below the ear. An aspiration biopsy of one of these nodules was positive for squamous cell carcinoma.

The recurrence of the facial paralysis was probably due to active disease deep in the parotid fossa. Hence the case was not suitable for a parotid implant. In addition there was a 3 cm. mass in the lower third of the neck. The recurrence in the parotid fossa and nodules below the ear were included in two oblique portals using wedge filters, delivering a tumor dose of 5,900 r maximum and 5,100 r minimum in five weeks. The lower mass was irradiated with a single field (5,700 r in four weeks). The photograph was taken in the third week of treatment.

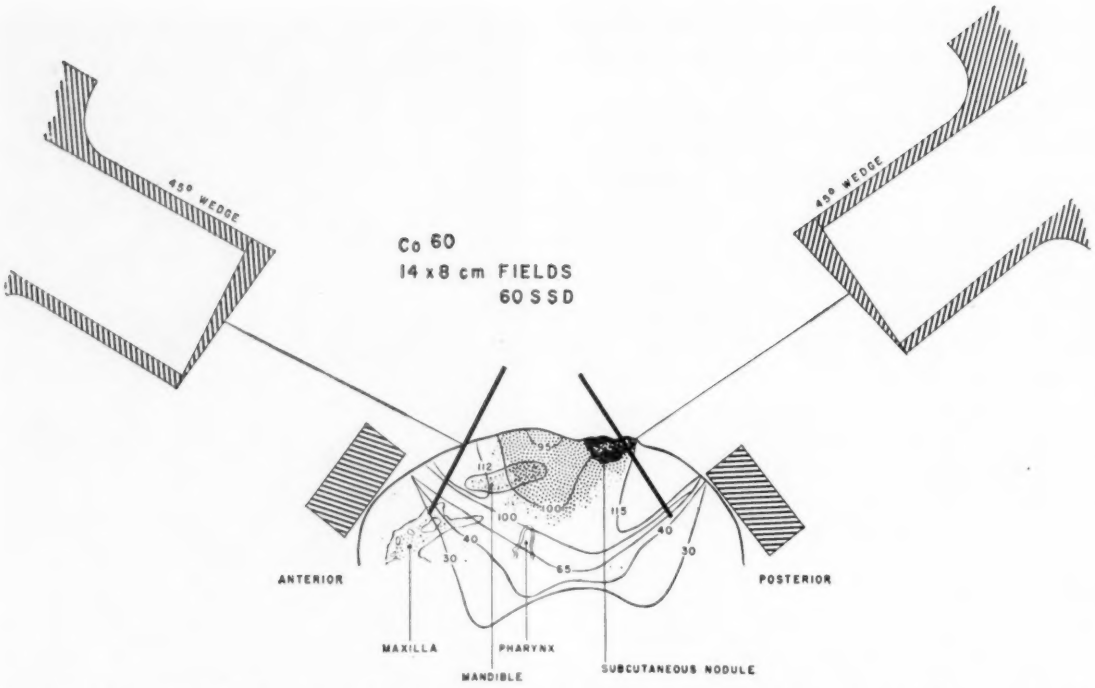


FIG. 5*E*. Two oblique fields with wedge filters produce an ideal volume distribution and enable one to irradiate homogeneously the whole of the parotid fossa and the deeper parts of the upper neck. One can, by changing the obliquity of the beams, the separation of the portals, and the skewness of the filters, vary at will the depth and the area covered by the 100 per cent isodose curve. The dose falls rapidly so that one avoids giving excessive doses to the brain in the vicinity of the base of the skull.

Anterior Faucial Pillar and Retromolar Trigone: A tongue-pterygoid implant is the treatment of choice for early lesions. Adequate irradiation can be delivered to the more advanced ones through a homolateral field narrowed at the end of treatment on residual infiltration (Fig. 1*A*).

Base of Tongue: Patients with tumors of the base of the tongue are best treated by two opposing fields, producing a homogeneous dose from subcutaneous tissues to subcutaneous tissues. This is an ideal volume distribution as it includes the lymphatics of the carotid region and upper jugular chain which are almost always involved.

Oral Cavity: Tumors of the anterior two-thirds of the oral cavity not suitable for classical interstitial gamma-ray therapy present an infinite number of problems. Hence, the planning is a test of the clinical judgment and ingenuity of the therapist (Fig. 1*B*). The whole treatment is given either by external irradiation alone, or in combination with interstitial gamma-ray therapy or intraoral therapy (Fig. 4).

Larynx and Hypopharynx: Vocal cord tumors and early tumors of the supraglottic region are best irradiated with very small fields (4 by 5 cm.) carefully localized, in the same way as in conventional therapy. The only difference is, perhaps, that with the Cobalt-60 beam one can use a homolateral portal only instead of two opposing portals. The greatest attention must be given to edema of the arytenoid regions; the treatment is completed with 2 by 3 cm. portals with the penumbra reduced to a minimum. In the more advanced supraglottic or pyriform sinus tumors, the draining lymphatic areas, *i.e.*, carotid and upper jugular lymph nodes, must be included and this is usually accomplished by trapezoidal portals.

In the postoperative radiation therapy of advanced laryngopharyngeal tumors,

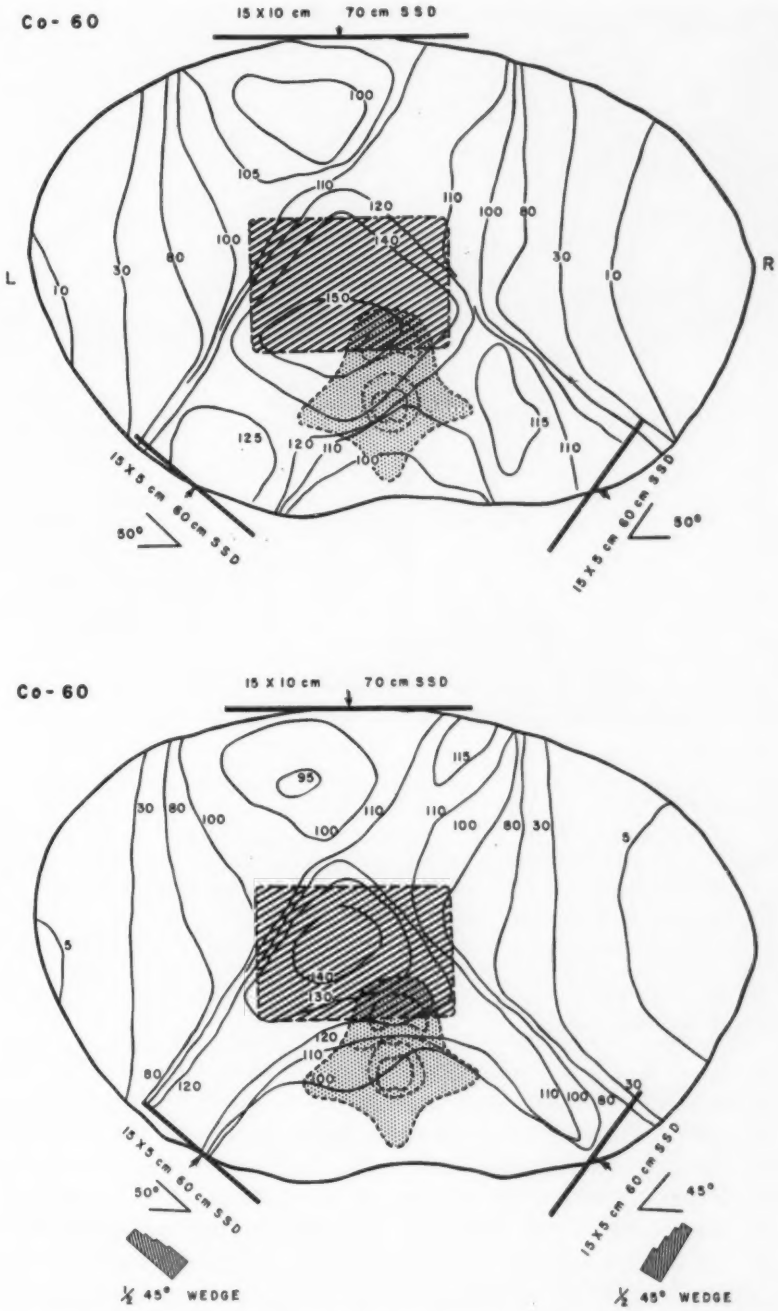


FIG. 5*F*. Treatment of peri-aortic nodes. A three field arrangement, the two posterior oblique fields fitted with half-wedge filter (lower pattern), gives a good volume distribution with protection to the spinal cord. The advantage of using a wedge filter instead of narrowing the posterior fields to avoid the spine, is the increase in assurance of anatomical coverage of the lesion. The same type of pattern can be used in tumors of the esophagus.

the whole neck must be included because of the diffuse lymphatic involvement. This is responsible for the failure of surgery alone. In those cases in which there is massive involvement of the pre-epiglottic fossa and/or the base of the tongue, interstitial gamma-ray therapy must be added. This may be in the form of a volume

FIG. 6*A*. Patient in actual treatment position. In this instance, 5 to 6 cm. were gained by compression of the abdomen. Some of the compression cones and wedge filters for different size of portals are shown: *A*, compression attachment with lead block to produce a 4 cm. split width at 10 cm. under the surface; *B*, adaptor for 5.5 cm. split width at 10 cm. depth; *C*, adaptor for 7 cm. split width at 10 cm. depth; *D*, adaptor for 7 cm. split width with 45° wedge filters wedging 2 cm. of each field; *E*, compression attachment showing the displaced lead block for asymmetrical treatment; *F*, compression attachment for 14 by 8 cm. field at 60 cm. source-skin distance; *G*, compression attachment with cone for 15 by 5 cm. field at 60 cm. SSD.

The central lead slab producing split fields is on a movable carriage to fit symmetry of the volume distribution from the radium sources. Various thicknesses of this central lead slab can be simply supplied by saddling over the block (*A*) which provides a thickness of 4 cm. at 10 cm. depth (*B*, *C*, *D*). Half-wedge filters are also fitted to the lead slabs (*D*).

implant of the submental region into the base of the tongue. An attempt to cover these regions adequately by external beam alone renders the treatment intolerable because too large a volume of the oral cavity must be irradiated.

Pharyngeal Wall Tumors: Tumors of the lateral or posterior pharyngeal walls, either at the level of the oropharynx or the hypopharynx, are irradiated by two opposing elongated portals. These produce a satisfactory volume distribution, and deliver a homogeneous dose from subcutaneous tissues to subcutaneous tissues, including the lymphatics of the jugular chain. If the tumor is located unilaterally on the pharyngeal wall, a heavier given dose to the homolateral portal (or even a single homolateral field) shifts the maximum dose to the site of the tumor.

Parotid Fossa, Pre-auricular Nodes and Middle Ear: There are a variety of clinical circumstances in which these three adjacent regions are involved in a neoplastic process. A malignant tumor may be primary in the parotid, or an infiltrating primary malignant tumor of the skin of the ear or external auditory canal may have gone out of control despite local therapy. The lesion may be a primary squamous cell carcinoma of the middle ear. Further metastatic invasion of the parotid fossa may have oc-

curred. Primary squamous cell carcinomas of the skin of the temple, pre-auricular region or ear, and primary squamous cell carcinomas of the posterior third of the oral cavity, pharynx and extrinsic larynx, have the tendency to metastasize to the lymphatics located high in the neck, including the lymphatics of the lower pole of the parotid. Following a radical neck dissection, recurrence of the disease deep in the parotid fossa is not an infrequent happening. This is clinically manifested by swelling in that region and the appearance of facial paralysis. In the primary squamous cell carcinomas which have metastasized to the pre-auricular nodes, the next relay is also in the lower pole of the parotid; there is no successful therapy without treating these deeper lymphatics and the gland itself. Surgical attempts to remove malignant involvement of the parotid by radical parotidectomy, including resection of the ascending ramus of the mandible, are rarely successful. Often, at surgery, the operator sees tumor invading the base of the skull.

Whether the tumor is primary or metastatic there is a common problem of planning with slight modalities. All the parotid fossa and the base of the skull should be treated to varying depths, usually 4 to 6 cm., depending upon how deep one has demonstrated, or thinks the disease has advanced. The external auditory canal, mastoid region, petrous bone and the deeper aspects of the upper neck must also be treated, as one block of tissue, to a high level of radiation. High dose radiation of such a large block of tissue is difficult with the conventional voltages but can be done if one uses very long protraction. If one is dealing with a probable localization in the lower pole of the parotid, a double plane implant of the parotid region combined with single field external irradiation has at times been successful. However, results are inconsistent. The skin sparing effect and the lesser bone absorption of the Cobalt-60 beam warrant extensive trials to determine what can be done in this frequently occurring problem in cancer therapy of head and neck tumors.

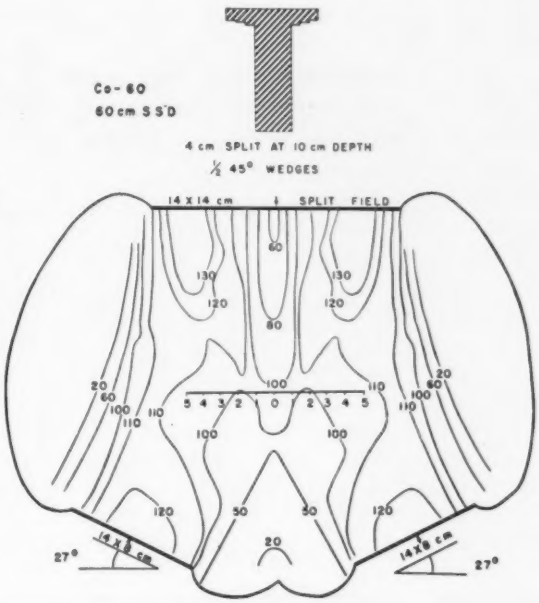


FIG. 6*B*. Pattern used with advantage in external irradiation prior to radium therapy. An anterior split field, 14 by 14 cm., tilted 10° to the feet and two posterior oblique portals produce a volume distribution with a tumor dose increasing from the midline to the pelvic walls. This pattern can be used also with transvaginal therapy.

Due to the skin sparing effect, one can deliver a high dose to a single lateral field with a tissue dose at 5, 6, and 7 cm. deep, still sufficiently high to be effective. This of course results in a high dose to the tissue of the brain stem, hypothalamus, temporal and frontal lobes. In two instances of treatment by one single lateral field to a high dose, cerebral vascular accidents developed during and shortly after the completion of treatment. The patients were elderly and it might have been coincidental. However, the delivery of a high dose to large volumes of nervous tissue should be avoided in view of the risk of this most severe complication. It also produces severe mucositis in all of the nasopharynx and oropharynx. Oblique beams with wedge filters provide an ideal way to deliver a high dose to whatever block of tissue one wants to delineate, with fast fall-off of the dose below the determined depth at which disease is present

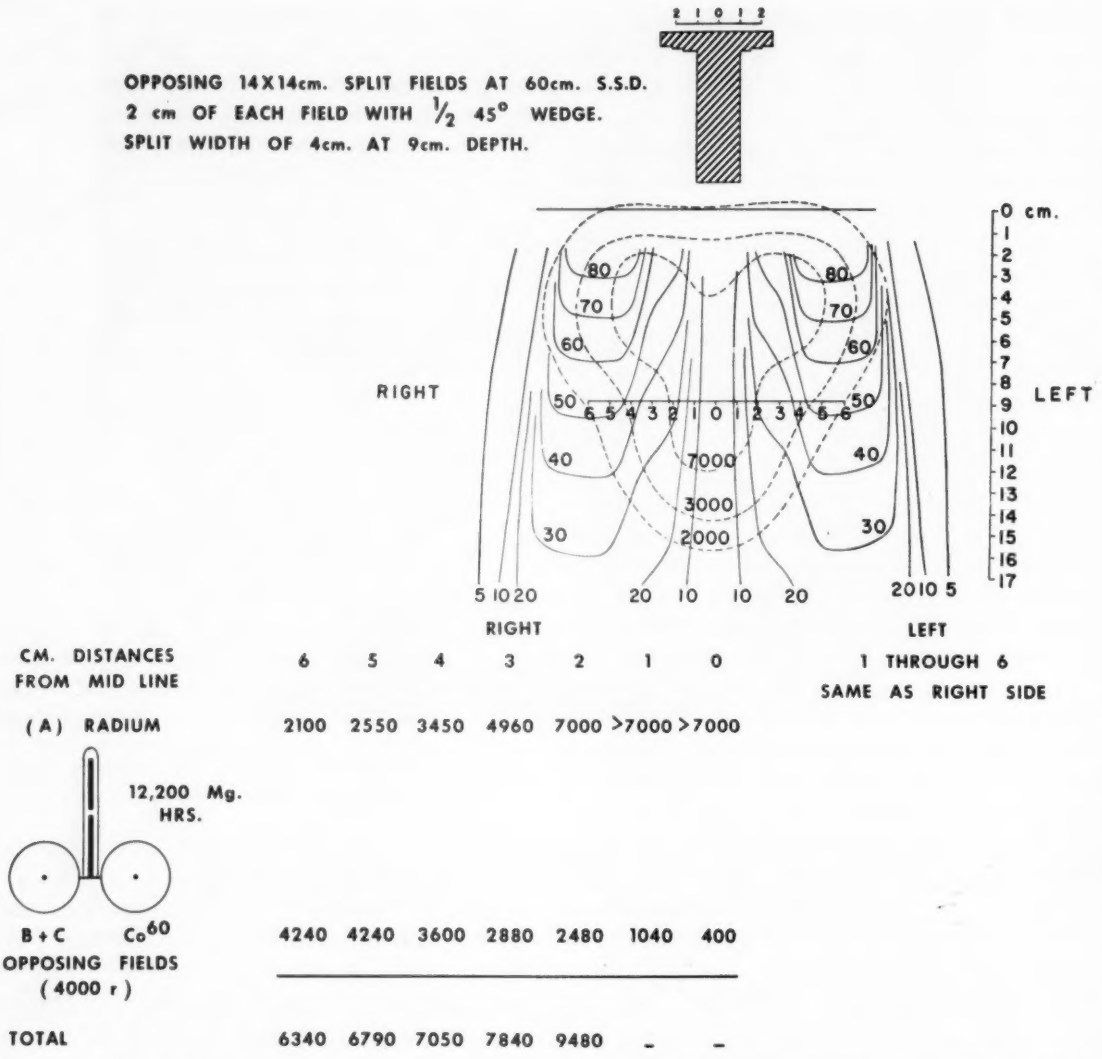


FIG. 6C. Symmetrical volume distribution from radium sources and dovetailing, by the use of a central lead slab and half wedge filters, of the external radiation using two opposing portals. The anteroposterior diameter (AP⊙) of the patient (measured after compression) is 18 cm. The dovetailing is best illustrated by superimposing one isodose curve over the radium volume distribution.

(Fig. 5*D* and 5*E*).

Metastatic Neck Nodes: The radiotherapeutic management of metastatic spread to the lymphatics of the neck from primary tumors of the head and neck must be based on the detailed knowledge of both the anatomical spread and the likelihood of response to irradiation. This response is not only a function of the histopathology of the primary tumor but also of its site of origin. It is well known that tumors of the same grade originating in different regions produce metastatic nodes with a different response to irradiation. By and large, only squamous cell carcinomas originating in the posterior third of the oral cavity, and the oro-, naso-, and hypopharynx, have lymphatic spread amenable to radiation therapy. In those tumors originating in the anterior two-thirds of the oral cavity, lip or skin, radical neck dissection is the treatment of choice unless there are definite contraindications. These contraindications may be medical or surgical, the extent and/

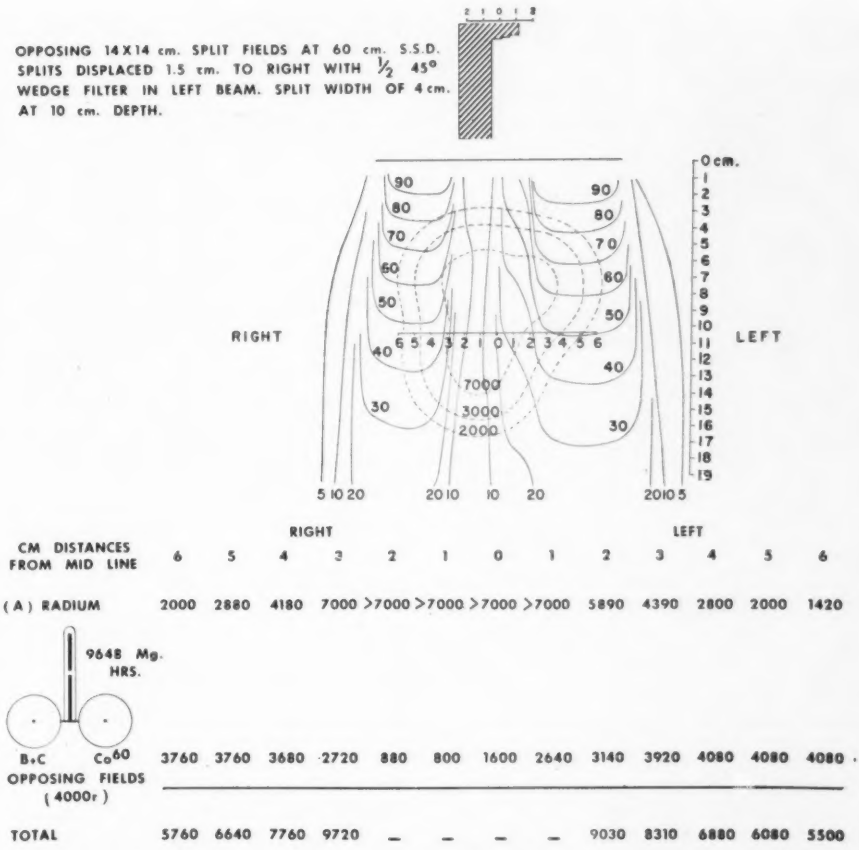


FIG. 6*D*. Fitting to an asymmetrical volume distribution from radium by shifting, on the carriage, the lead slab and using the half wedge filter only on one side.

or attachment of the nodes rendering the surgical procedure impossible, futile, or even conducive to diffuse carcinomatosis of the neck.

In those tumors, usually anaplastic squamous cell carcinomas originating posteriorly in the oral cavity or the pharynx, irradiation of the primary and the lymphatics must be performed in continuity. Due to the diffuseness of the spread, the involvement of the spinal accessory chain, posterior cervical triangle and supraclavicular area lymphatics must be assumed. Hence, these areas must be included, even if there are no palpable nodes at the time of examination. Also, because of the rich lymphatic network of the posterior pharyngeal wall, contralateral metastases are frequent. Consequently, in most cases, both sides of the neck must be irradiated down to the level of the clavicle (Fig. 2*B*). The irradiation of these lymphatic areas is best performed by the use of anatomical fields. Long fractionation is essential, and after the maximum tolerable has been given to the whole neck, small tangential fields should be used on residual masses. These fields are positioned in order to avoid the spinal cord and the most sensitive structures of the pharynx and larynx.

In the squamous cell carcinomas of the anterior two-thirds of the oral cavity, and in some of the laryngopharynx squamous cell carcinomas, radiotherapy is employed for a wide variety of purposes. It may be used to produce a temporary control of palpable nodes until the primary lesion, treated either by surgery or irradiation, has evolved to the extent where a radical neck dissection is indicated. Hard, fixed,

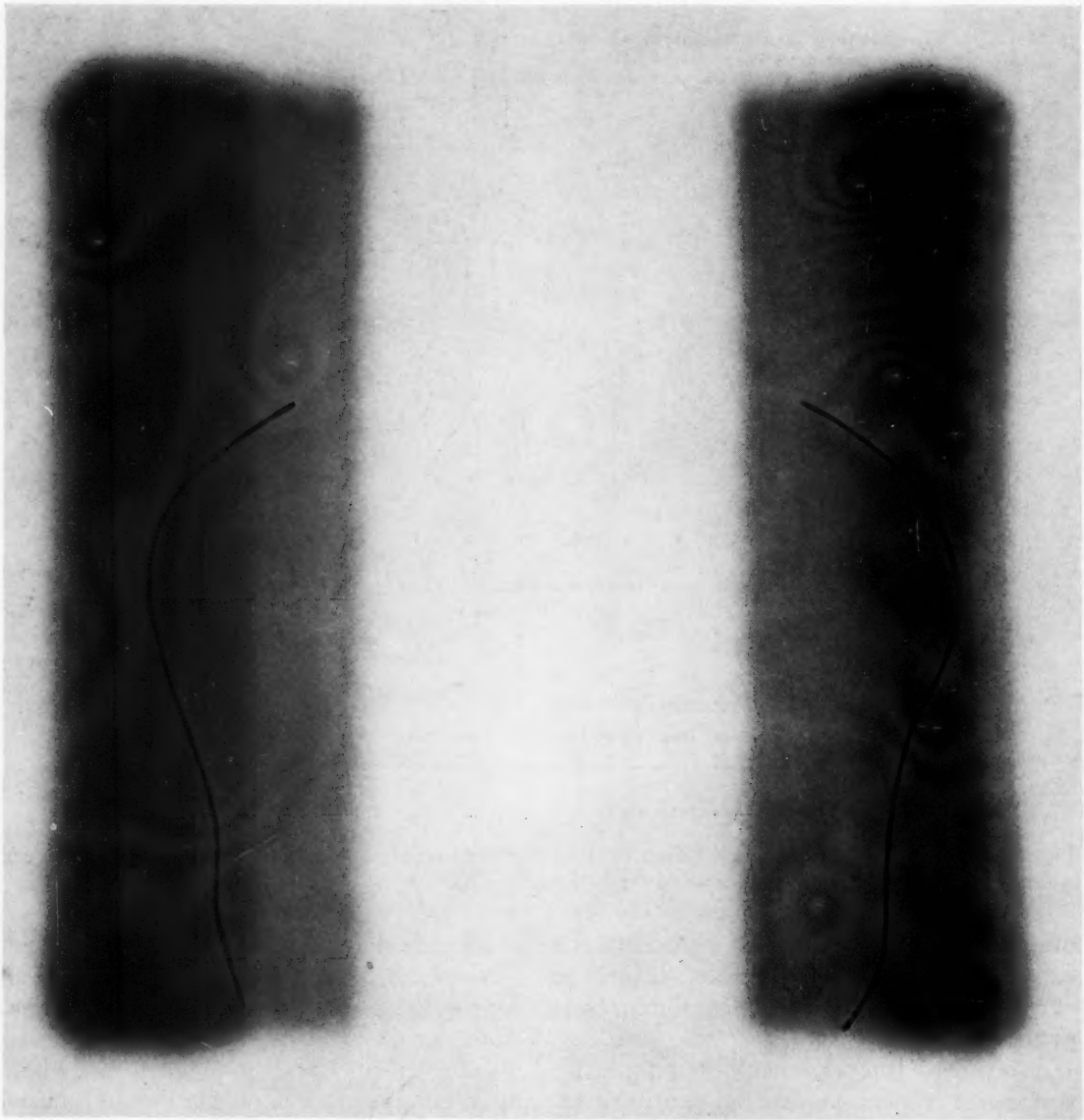


FIG. 6*E*. Films are taken routinely for checking of the position of the pelvic portals. The bony detail is sufficient to identify the structures. One sees the shades of gray due to the wedge filter. The penumbra is also seen on the lateral aspect of the portals.

inoperable nodes can at times be irradiated best by delivering a high dose to a small field covering the node only. This produces regression, and eventually almost complete sterilization of the tumor mass. A radical neck dissection or "commando type" operation may then be performed. Interstitial gamma-ray therapy, usually in the form of a radium implant (localized or covering the whole neck) also plays a great role in the management of metastatic neck nodes. This interstitial gamma-ray therapy can be combined with external beam therapy. Preoperative irradiation in the borderline operable cases makes recurrences or diffuse carcinomatosis of the neck less probable.

It is beyond the scope of this paper to discuss the great variety of circumstances in which radiotherapy can be used alone or

combined with surgery. External irradiation is only possible with the use of an accurately adjustable light localizer which allows any shape of the anatomical portals. Long fractionation and a thorough knowledge of the responses of different tumors are necessary. The responses, as mentioned earlier, depend upon the histopathology and site of origin of the tumor; these two factors determine both the areas to be covered and the total dose which is likely to be effective. Dosage also varies in terms of the over-all planning, that is treatment by external irradiation alone, in combination with interstitial gamma-ray therapy, or in combination with radical surgery.

Doses and fractionation will probably be different from those in the 250 kv. range. Part of the purpose of the long fractionation in that voltage range is to allow high doses to be delivered to the nodes without excessive damage to the skin. Considerable clinical investigation should be done to find the optimal tumor dose-time relationship with the Cobalt-60 beam. Several cases of radical neck dissection, performed after high doses to the neck, have already demonstrated the advantage of the skin sparing effect. There is no delayed healing, and as yet no case of necrosis has appeared at the Y of the skin incision. This opens avenues for combination with surgery, for, when conventional therapy is used, the wound heals poorly. Occasionally, uncontrollable necrosis occurs at the Y of the incision, located in the vicinity of the carotid even if the surgeon has made a modified incision, and results in fatal hemorrhages.

Tumors of the Thoracic Cage: The malignant tumors of the thoracic cage which come to radiotherapeutic management are either the squamous cell carcinomas of the esophagus and bronchi or the lymphomas located in the mediastinum. For the lymphomas, simple arrangements of portals—most often two opposing portals—are used to deliver the necessary tumor doses. The most radical surgery and well planned radical radiotherapy, in truly unselected series of the squamous cell carcinomas, result in only a small percentage of the patients salvaged, irrespective of how radical the treatment is. By performing thoracotomies in almost unselected material, increased knowledge has been obtained on the mode of spread and extension of those tumors. When diagnosed, the vast majority have already spread far beyond the confines of local therapy. This evolution of thoracic malignant tumors is independent of the wavelength employed in treatment. Hence, very little can be expected in increased cure rates from the advent of supervoltage therapy. Radical therapy can at times do more harm than good. Sound clinical judgment must be exercised to gauge the therapeutic purposes in patients whose disease is widespread and extremely ill defined.

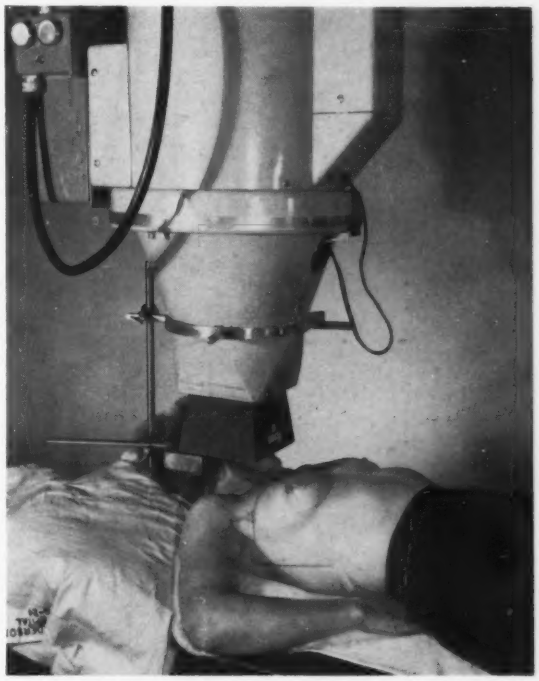


Fig. 7*A*. Anterior field covering the supraclavicular region and anterior axilla. It includes the first intercostal space.

There is a trend in the treatment of patients with squamous cell carcinomas of the esophagus to reserve for radiation therapy those located in the upper half of the thoracic esophagus. Extensive series of

Fig. 7*B*. Posterior axillary field.

patients with squamous cell carcinomas of the esophagus, treated by a variety of radiation techniques, have been studied. The best palliation, with the same percentage of cures or long-lasting arrests, has been secured by techniques aiming only at producing regression of that part of the tumor which blocks the lumen of the esophagus, no attempt being made to include all probable disease. That is, the best results were obtained when the portals, either by rotation or stationary technique, included only the grossly distorted section of the esophagus, as demonstrated on the esophagram. If one wants to be curative, one must include long segments of esophagus above and below, and large areas of mediastinum as the lymph nodes in that area are almost always involved. If supervoltage is to be used to its best advantage one should choose the technique of two opposing portals, or one anterior and two posterior oblique portals, which can be used easily at 1 or 2 mev. or higher voltage levels, and not at 250 kv. Radical therapy is warranted only if one has attempted to rule out the existence of distant spread. In particular, the presence of subdiaphragmatic retroperitoneal lymph nodes should be ruled out, as we know they are frequently involved. Cancers of the esophagus are not perfect cylinders, but tortuous elongated tumors. Hence they do not stay in any beam of radiation during rotation if the portal is not constantly adjusted. Therefore, if one chooses rotation therapy, it must be done under fluoroscopic control. As barium is barely visible with a Cobalt-60 beam, image amplifiers and television setups will be necessary.

The place of radiation therapy in bronchogenic carcinoma ranges from the delivery of gentle doses for simple relief of pain to higher, but still moderate, doses to produce regression of compressing mediastinal nodes. It also may be used to reopen a blocked bronchus to prevent infection distal to the block. Occasionally, at the end of the spectrum, one attempts to be radical in the treatment of tumors which are not surgically resectable because of their location, but which apparently are still localized.

Pelvic Malignancies. In patients with pelvic malignancies, the planning of external irradiation with a Cobalt-60 beam must follow the same lines of thought as in conventional voltages. The 250 kv. equipment can deliver, except in obese patients, doses over the whole of the true pelvis or the pelvic wall alone which overtax the tolerance of small intestine, bladder, rectum and connective tissue structures without overtaxing the skin. In addition, with anatomical planning, there is no need to go through large thicknesses of bone. In our experience with nearly 1,000 cases of pelvic malignancies treated with external irradiation, there has not been one case of femoral neck fracture. The tolerance of the inner organs to a 1.2 mev. beam is no better than to conventional voltages, once the electronic equilibrium has been reached, *i.e.*, a few millimeters below the skin. A variety of patterns must be utilized, depending upon the purpose. Total pelvic irradiation may be employed for shrinking

TABLE A

COBALT-60 14 X 14, 60 cm SSD, CENTER SPLIT 4 cm AT 10 cm DEPTH.
POSTERIOR AND ANTERIOR FIELD WITH 1/2 45° WEDGES

AP⊙	15 cm	16 cm	17 cm	18 cm	19 cm	20 cm	21 cm	22 cm	23 cm	24 cm	25 cm
% MIDLINE	10	10	10	10	10	10	10	10	10	10	10
% 2 cm OFF MID	70	68	66	64	62	59	56	73	50	47	44
% 5 cm OFF MID	119	115	111	107	103	100	96	93	89	86	83

TABLE B

COBALT-60 14 X 14, 60 cm SSD, CENTER SPLIT 4 cm AT 10 cm DEPTH

AP⊙	15 cm	16 cm	17 cm	18 cm	19 cm	20 cm	21 cm	22 cm	23 cm	24 cm	25 cm
% MIDLINE	10	10	10	10	10	10	10	10	10	10	10
% 2 cm AND 5 cm OFF MID	119	115	111	107	103	100	96	93	89	86	83

TABLE I

Depth dose tables (expressed in percentage of 100 r given dose to each portal) at mid-pelvis for opposing split fields for various thicknesses (AP⊙) measured after compression. In Table A there is a half wedge filter; in Table B there is no wedge filter in addition to the central slab. The arrangement without filter is best used with transvaginal therapy as there is no lateral throw-off. The other pattern fits best the volume distribution of radium. It must be noted that the midline is much more efficiently screened than at the 200–400 kv. range where, due to the side scatter, approximately 40 per cent of the dose at Point B (5 cm. off the midline) reaches the midline.

a bulky or infected tumor of the cervix; or an arrangement of portals aiming at the lateral aspects of the parametria and the pelvic wall lymphatics may supplement intracavitary radium therapy (Fig. 6). The midline structures can be screened much more efficiently (Table 1) than at the 200–400 kv. range where, due to the side scatter, approximately 40 per cent of the dose at Point B reaches the midline and 50 per cent Point A.

Breast. Radiotherapy has many purposes in the treatment of patients with breast cancer. These include postmastectomy irradiation of the regional lymph nodes which are not surgically resectable, or at least easily resectable, *i.e.*, apex of axilla, supraclavicular region and internal mammary chain nodes. Radiation therapy is also used as the sole form of treatment in patients with inoperable tumors. Extensive investigation of Cobalt-60 beam therapy will have to be done before one can determine whether or not it can be used safely to advantage. In the irradiation of the lymphatics of the apex of the axilla, supraclavicular region and internal mammary chain following a simple mastectomy, the greater depth dose of the 1.2 mev. beam may produce damage to the mediastinum and lung structures which might offset the advantages of the skin sparing effect. Using a beam of 3 mm. Cu half-value layer, tumor doses of 3,500 to 4,000 r can be delivered in three weeks to those nodes with acceptable acute and late skin reactions. Radiation pneumonitis rarely occurs. The skin sparing effect of the 1.2 mev. beam is thought to be most beneficial in the preoperative treatment of cases which are technically operable, but which are known to produce a high incidence of local recurrences if a radical mastectomy is performed first. Radical mastectomies have

Fig. 7*C*. Medial tangential field. A plastic breast bridge with spirit level is used to position the portal, but is not left during treatment. Same technique for the lateral tangential field.

Fig. 7*D*. Time exposure to show the illumination of the portal with the light localizer. Small fields over the breast itself using a small plastic breast bridge squeezing the breast. This is used at the end of treatment to increase the dose to a residual mass in the breast. The squeezing bridge stays during the treatment. It is useful as the skin is always involved around big masses which require additional tumor doses. The build-up is produced in the plastic plate, thereby increasing the skin dose. This technique is always used when irradiation is planned to be the primary method of treatment.

been performed in several cases following preoperative treatment with the Cobalt-60 unit, delivering tumor doses of 4,000 r to the breast and 4,000 to 4,500 r to the lymph node areas in three and a half to four weeks (Fig. 7). The surgical procedure was done and the wound healed as if no radiation had been given. This is a definite advantage over the 250 kv. equipment, however, one gains the impression that radiation pneumonitis is more frequent and more severe. This is easy to explain in view of the greater dose to lung tissues because

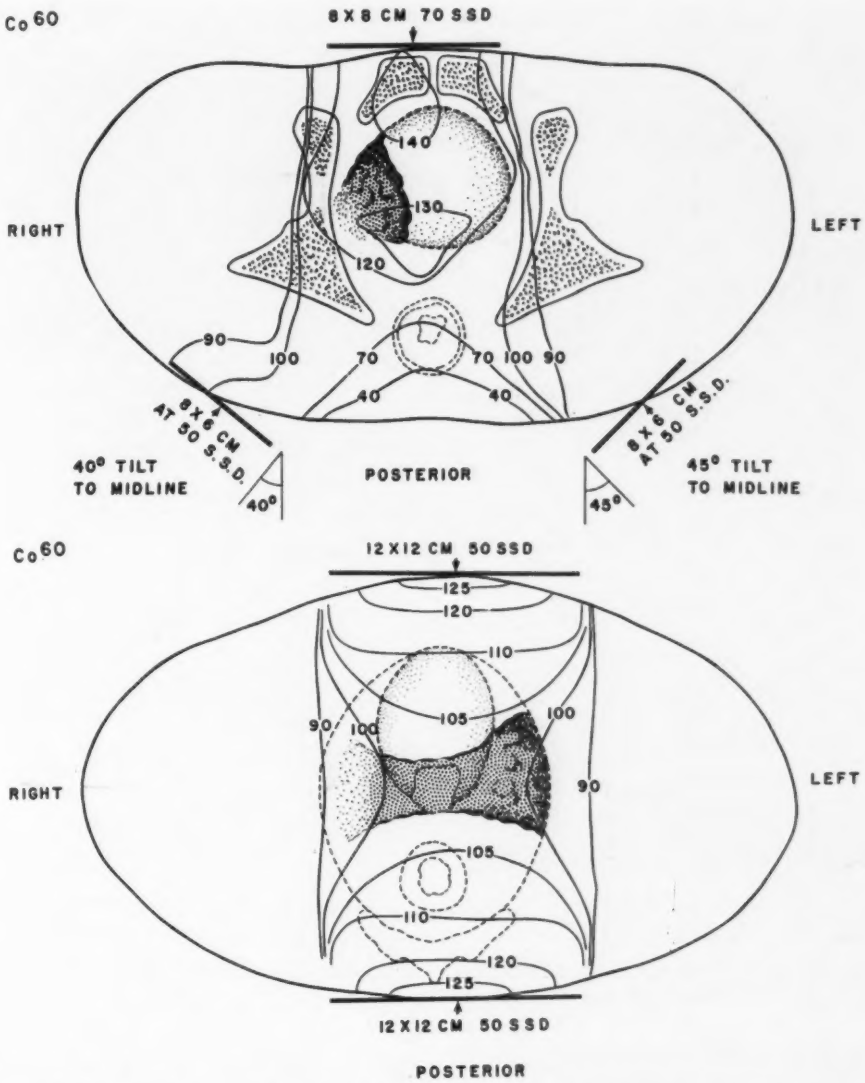


FIG. 8*A*. *Upper*. Infiltrative lesion of the right side of the base of the bladder about 4 cm. in diameter, obscuring on cystoscopy the right side of the trigone and the right ureteral orifice. Bimanual palpation shows an ill-defined induration to the right of the bladder. Biopsy shows transitional cell carcinoma infiltrating the bladder wall and prostate gland. The volume distribution, using three fields, is slightly asymmetrical in order to include the right pelvic wall. A given dose of 4,800 r was delivered to the three fields producing a minimal tumor dose of 5,700 r and a maximum of 6,700 r in five weeks.

Lower. Segmental resection performed previously for a papillary tumor implanted behind the orifice of the left ureter, infiltrative at the base. On rectal examination there is a large tumor mass continuous with the prostate, reaching the pelvic wall on the left. The tumor mass bulges also toward the right side, but does not reach the pelvic wall. The histopathology is papillary transitional cell carcinoma, Grade 3, with infiltration of the bladder wall and prostate gland. Due to the involvement reaching the left pelvic wall and almost the right pelvic wall, the treatment was planned with two opposing portals. A tumor dose of 4,000 r was delivered in four weeks, the given dose being 3,900 r to each portal.

of the lesser bone absorption in the ribs (irradiated end on and so not a negligible factor in 250 kv. equipment). In addition, larger volumes of lung tissue are irradiated because of the penumbra, which at 60 cm. source-skin distance is appreciable. Cases must be followed for a long period of time to determine the incidence and severity of

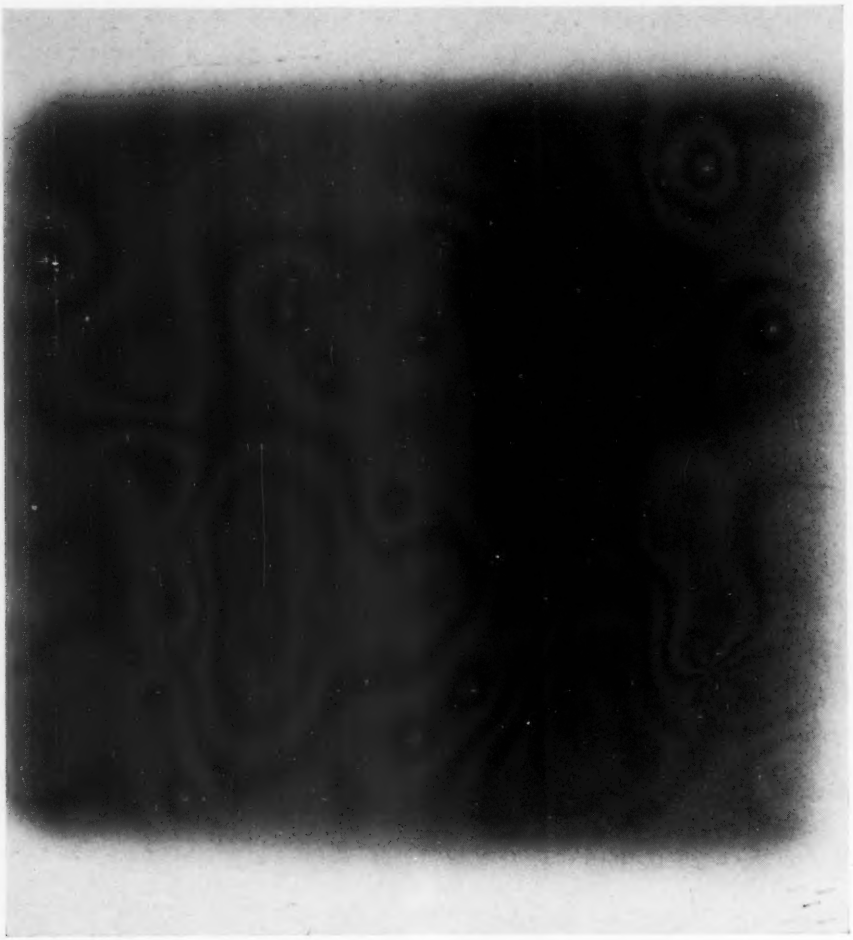


Fig. 8*B*. Film taken in the actual treatment position for checking of the accuracy of the posterior oblique portals of case of Figure 8*A*. The air-filled bladder is well seen.

sequelae to lung and connective tissues, in particular, massive fibrosis of the axilla.

The same skin sparing effect can be used to advantage in tumors which are handled by irradiation alone, but the same caution must be exercised.

The modalities of technique must be kept essentially the same as they are determined by the anatomy of the area and the pathologic behavior of the disease. The definite clinical radiobiological advantages of the Baclesse technique, *i.e.*, its long fractionation, ought to be adapted to the Cobalt-60 beam with probably some changes in the time and tumor doses. The practice of reducing the size of the portals on the residual masses after a minimum tumor dose has been given to the whole area, including the regional lymph nodes, must be possible if one wants to achieve the same good results. This is an instance in which a light localizer, tungsten slabs and flexibility of equipment are essential. With the unit at our disposal we can use the Baclesse technique with the same flexibility as with 250 kv. equipment.

Genitourinary System. Retroperitoneal metastatic lymph nodes from seminoma of the testes do not require high doses and can be simply irradiated by opposing portals with 250 kv. Metastatic nodes from embryonal carcinoma or teratocarcinoma necessitate increasingly higher doses. A three field arrangement, one anterior and

two posterior oblique portals with the use of a half wedge filter for the posterior oblique portals and/or greater given doses produces a satisfactory volume distribution (Fig. 5*G*).

The management of malignant epithelial tumors of the urinary bladder is changing. In those tumors which are superficially infiltrative, *i.e.*, if the muscularis mucosae is not involved, local means of control such as electrocoagulation, segmental resection, or interstitial gamma-ray therapy are the treatments of choice. Total cystectomies associated with radical dissection of the pelvic lymphatics have been performed in large numbers of cases in the last ten years, and have cast a new light on the behavior of urinary bladder tumors. It is now known that if the muscularis mucosae is involved, pelvic lymphatics are almost always involved and distant metastases are frequent. Therefore, the volume irradiated must include not only the primary in the bladder but also part, or even all of the pelvic lymphatics. However, the volume of tissue then becomes too large to allow the delivery of curative tumor doses. One must compromise, depending upon the merits of each individual case, and include the paravesicular tissues which are most likely to be involved. With the increasing disappointment in the results of radical surgery, more tumors of the urinary bladder will be irradiated with supervoltage therapy, but trials will have to be made before a definite modality of treatment emerges as the best. A three field arrangement, one anterior (8 by 8 cm.) and two posterior oblique portals (8 by 6 cm.), gives a satisfactory volume distribution. The anatomical accuracy is easily checked by film exposed with the Cobalt-60 unit in actual treatment position with air in the bladder. Depending upon the size of the lesion and its location in the bladder, the planning may be made more or less asymmetrical in order to include the most likely involved pelvic lymphatics. Rectal examination and bimanual examination under general anesthesia, or saddle block, is necessary to define the extent of invasion of paravesicular tissues, and fields up to 10 by 10 cm. anteriorly, 10 by 8 cm. posteriorly or two opposing fields up to 12 by 10 cm. are used. The doses have to be decreased as the size of the portals is increased. In many instances a suprapubic cystotomy has been performed for exploration or partial resection. It oftentimes produces adherence of the dome of the bladder to the abdominal wall. The volume distribution of the three field arrangement is ideally suited if, as is often the case, the whole bladder must be included (Fig. 8).

FIG. 8*C*. Lateral film showing the attachment, following cystostomy, of the dome of the bladder to the anterior abdominal wall. The volume distribution of Figure 8*A* is ideally suited for irradiation of the whole bladder.

CONCLUSIONS

The concept that radiotherapy is the discipline concerned with homogeneous

fields of energy absorption from controlled beams of ionizing radiation in predefined volumes of tissues is an abstract concept detached from clinical realities. The knowledge of the spatial distribution of the ionizing energy is essential but it would be a gross and most damaging misconception to believe that it is all important and can replace clinical judgment, based on experience. The geometrical problem in radiotherapeutic planning is only a part of a larger problem, as physical means of altering cancer cells can only be used successfully on a background of medical thinking. The availability of higher energy levels does not change either the clinical biological behavior of cancers, to which one must fit the modality of attack, or the tolerance of the inner structures once the electronic equilibrium has been reached. Well tested radiotherapeutic methods proven successful with conventional voltages must be preserved at higher energy levels if one wants to do at least as well. One may eventually hope to do better, if one can use to advantage, without loss in other ways, the characteristics of the high energy beams. If one chooses to use the word "shaping" for radiotherapeutic planning, it must be recognized that the shaping begins with the evaluation of what can be achieved in the individual case in the light of the natural life of this disease. Careful evaluation of the justified radicalism and of the areas to be included is made on the probability of extensions and likelihood of response. The planning must then be carried on according to the different radiosensitivities of the various components of the tumor. All of this is strictly clinical. Then the geometrical problems begin. Even then the geometry of the patterns is determined by the anatomy and the path of contiguous extensions and lymphatic spreads. A predetermined tumor dose is only a tentative objective in the planning, and both the geometry and the final tumor dose are subject to changes made necessary by the response of the tumor and the reactions of the supporting structures. This guidance of the radiotherapeutic treatment is purely a clinical procedure.

Supervoltage, including Cobalt-60 or Cesium-137 beams, is not a panacea, and does not dispense with the painstaking clinical work that goes with the management of malignant disease. Clinical judgment is the essential prerequisite for the use of a physical agent in the nonquantitative, but nonetheless factual field of medicine.

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CLINICAL STATIONARY FIELD THERAPY WITH A COBALT-60 UNIT

PART II*

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THE design of a Cobalt-60 therapy unit is both clinical and physical in nature. The problems involved in the design of a trouble-proof "off-on" mechanism with adequate shielding during the "off" position, for safety of personnel, are mechanical and physical. The collimating device must be designed to fulfill clinical requirements. This is not as easy as for the 250 kv. machines because of the comparatively large size of the radioactive source and the thickness of shielding material necessary to reduce the beam of hard gamma rays to an acceptable level. The size of the source imposes the problem of the geometrical penumbra. With 250 kv. machines, there is no geometrical penumbra and the clinically effective beam coincides with the geometrical beam. With a Cobalt-60 unit, the geometrical penumbra becomes of importance since the source of radiation is large. The emission of secondary electrons from the collimator must also be considered to preserve the advantage of the small skin dose inherent in high voltage radiation. In addition, means should be available for further shaping of the beam.

DESIGN OF COLLIMATOR

The secondary electron emission can be dealt with adequately either by distance[3,5] or by use of electron filters.[6] The effect of distance can be measured by plotting the build-up ratio (maximum-to-surface ionization) for increasing collimator-skin distances.[4] Extensive measurements have been made by Johns with the University of Saskatchewan Cobalt-60 unit giving the general shape of this curve (Fig. 1). The practical collimator-skin distance for acceptable electron contamination was taken as 20 cm. Although the amount of electron contamination depends upon the design of the unit, the same practical distance has been found for similar units,[9] such as the Cobalt-60 unit in use at the M. D. Anderson Hospital[6] and a 2 mev. roentgen-ray generator[5] which is closely equivalent to a Cobalt-60 unit.

For short collimator-skin distances, the number of secondary electrons reaching the skin can be reduced slightly by using a material of intermediate atomic number as the inner lining of the collimator. A significant reduction in skin dose can be obtained by use of electron filters, particularly for large fields at collimator-skin distances of less than 5 to 10 cm. The effect of an electron filter of intermediate atomic number is shown in Figure 1. Measurements have shown that materials of low atomic number, such as lucite, should be avoided. Optimum results are obtained by use of a filter of intermediate atomic number having a thickness of the order of 0.25 mm. A filter of this thickness will attenuate the Cobalt-60 gamma-ray beam by about 2 per cent. Greater thicknesses will only reduce the dose rate without improving the skin dose.

Given doses of 6,000 r, *i.e.*, that dose at depth of electronic equilibrium, have been

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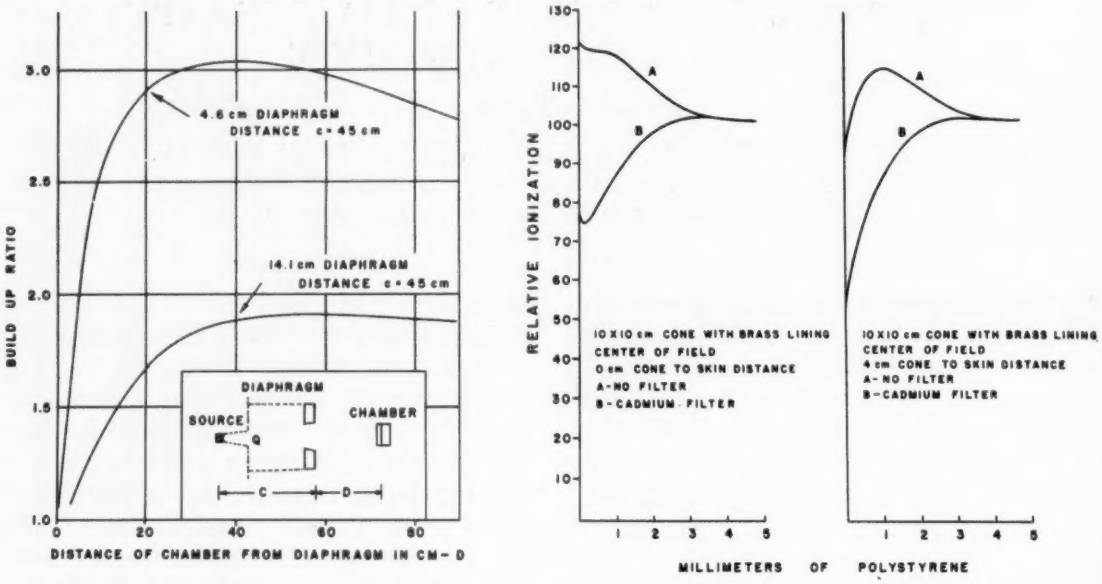

FIG. 1. Graphs showing two methods of reducing the effects of secondary electron emission from a Cobalt-60 uniit. On the left is shown the variation of build-up ratio with collimator-skin distance (Reproduced by permssion from Johns, H. E. *et al. Brit. J. Radiol.*, 1952, *25*, 302–308). On the right is shown the effect of an electron filter on skin dose. (Reproduced by permission from Richardson, J. E., *et al.*, *Radiology*, 1954, *63*, 25–36.)

delivered without electron filters in four weeks on 8 by 6 cm. areas of the head and neck with only moderate erythema, the skin reaction being as great on the exit as on the entrance side. When treating larger areas at short collimator-skin distances, and without electron filters, moist desquamation has been observed. Actually, attention should not be given to acute skin reaction alone, as it is now well established that the late damage in supervoltage is subcutaneous and can be most severe in the absence of an acute skin reaction.

Because of the large size of the source, increasing the collimator-skin distance could result in an appreciable penumbra if this distance becomes comparable to the source-collimator distance which is usually a constant. The geometrical penumbra varies with the size of the focal spot, or source, and the ratio of these distances. However, it is not a function of the field size, and so is proportionally greater for small areas (Fig. 2*B*). It is possible that in certain rotational techniques the penumbra may be used to advantage, but in the curative stationary field therapy the only part of the beam which can be used safely is that part in which the isodose curves are fairly flat. Otherwise, the coverage of the tumor is uncertain due to the very steep gradient of dosage rate in the penumbra

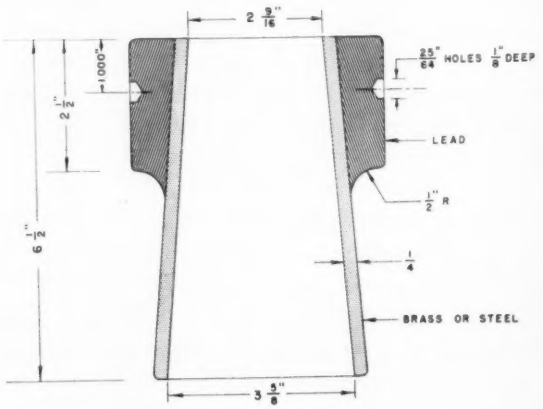

FIG. 2A. Cross-section of a cone. The cone is tapered from the edges of the source to minimize penumbra. Brass or steel inner linings are used to reduce secondary electrons. The transmission outside the geometrical field is 3 per cent (or less) of that at the center of the field.

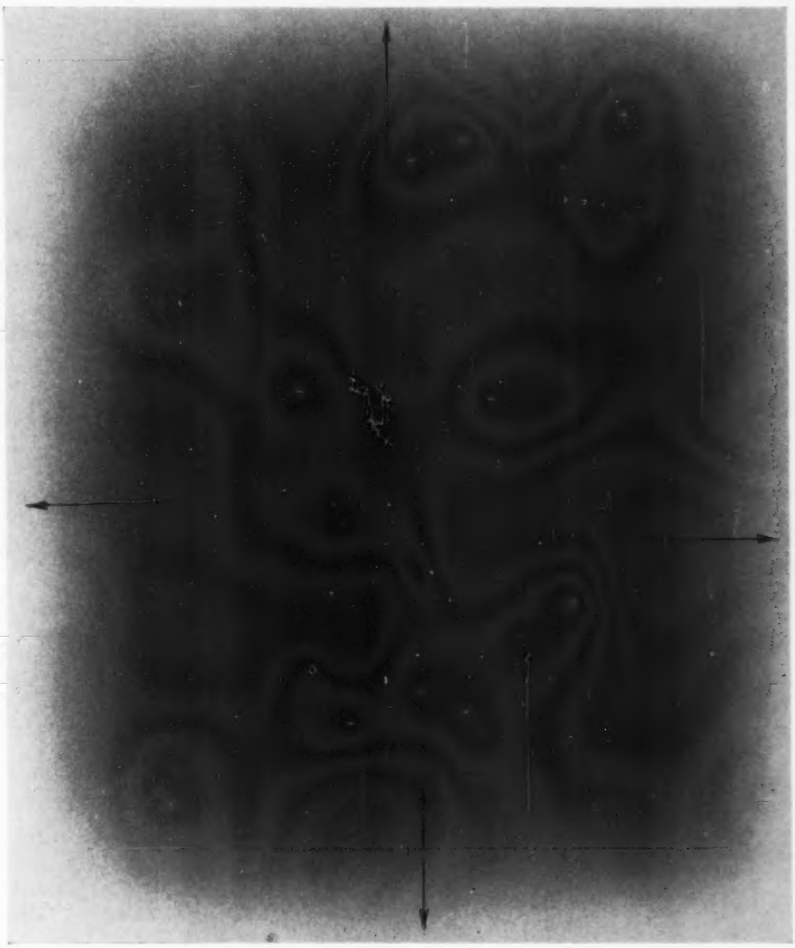

Fig. 2*B*. The geometric penumbra is well illustrated in this localization film of the nasopharynx. The film shows a definite region of penumbra 1.5 cm. wide for a 7 by 5.5 cm. field at 80 cm. source to film distance. At the site of the tumor, 70 cm. source to tumor distance, the penumbra is approximately 1 cm. for a 6 by 5 cm. field. This means that for an effective area of 30 sq. cm. there is a penumbra area of 26 sq. cm.

area. The concept that the penumbra can be used to treat the microscopic prongs of the tumor around the main mass is theoretically an attractive idea which would lead to an increase of what Paterson has called "geographical misses." This means that in anatomically precise irradiation, with high doses, for instance of tumors of the head and neck or pelvic wall lymph nodes, much larger volumes than necessary will have to be included (Fig. 2*B* and Fig. 6, Part I). The tolerance of the inner structures, *i.e.*, mucous membranes of the upper respiratory or digestive tract, bladder, rectum, or intestines, is highly critical, even more so in supervoltage therapy, because of the increased depth dose. The advantages of lesser skin dose and lesser bone absorption would be greatly offset by the damage to larger areas of mucous membrane of the head and neck regions, or vital organs of the pelvis or abdomen.

The collimating device of the unit built for the M.D. Anderson Hospital[2] was designed for the purpose of using radiotherapeutic techniques based on tested clinical principles. A light localizer and four movable shutters for defining gamma-ray beams provides squares and rectangles of all sizes, but the necessary thickness of

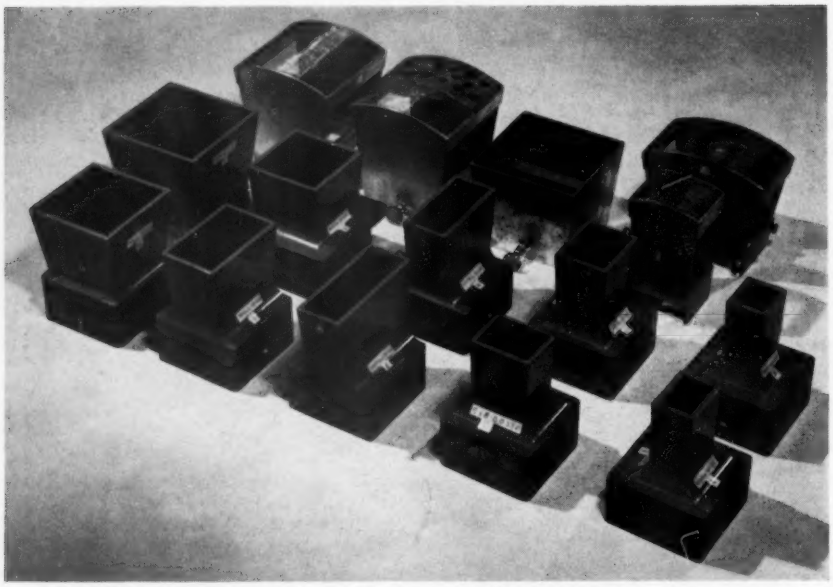

FIG. 3*A*. Set of cones including attachments for compression. The compression surface is made of brass mesh. Experiments were conducted to determine whether brass mesh or a plastic grid (1 mm. thickness) would give less skin reaction. The skin reaction, with either, following doses of 4,000 r through opposing pelvic portals (14 by 6 cm.) was only a faint erythema. Now only brass mesh is used.

COBALT-60 CALIBRATION CHART

(March 12 - May 12, 1954)

CONE		50 SSD	55 SSD	60 SSD	65 SSD	70 SSD	80 SSD
A	Field	5X4	5.5X4	5.5X4.5	6X4.5	6X5	7X5
	r/min	67.6	54.8	45.3	38.2	33.3	25.6
B	Field	6X4	6.5X4	6.5X4.5	7X4.5	7.5X4.5	8X5
	r/min	67.7	54.9	45.4	38.3	33.3	25.6
C	Field	7X5.5	7.5X5.5	8X6	8.5X6.5	9X7	10X7.5
	r/min	69.9	56.9	47.3	39.9	34.4	26.3
D	Field	8X6	8.5X6.5	9X7	9.5X7.5	10X8	11X8.5
	r/min	69.9	56.9	47.3	39.9	34.4	26.3
E	Field	12X5	13X5.5	14X5.5	15X6	16X6	18X7
	r/min	69.7	56.9	47.4	40.0	34.3	26.2
F	Field	15X5	16.5X5.5	17.5X5.5	19X6	20X6	22.5X7
	r/min	69.7	56.9	47.1	40.0	34.2	26.1
G	Field	12X7	13X7.5	14X8	15X8.5	16X9	18.5X10
	r/min	70.4	58.0	48.4	40.8	35.0	26.8
H	Field	10X10	11X11	11.5X11.5	12.5X12.5	13X13	15X15
	r/min	71.0	58.3	48.6	41.0	35.2	26.9
I	Field	12X12	13X13	14X14	15X15	16X16	18X18
	r/min	71.7	58.8	48.9	41.3	35.4	27.1
J	Field	14.5X14.5	16X16	17X17	18.5X18.5	19.5X19.5	22X22
	r/min	70.6	58.5	49.3	41.9	35.7	27.3

FIG. 3*B*. The cones are labelled with letters. The calibration chart gives the geometrical field size and maximum dose rate at different source-skin distances. The maximum dose rate varies slightly with field size for a fixed source-skin distance.

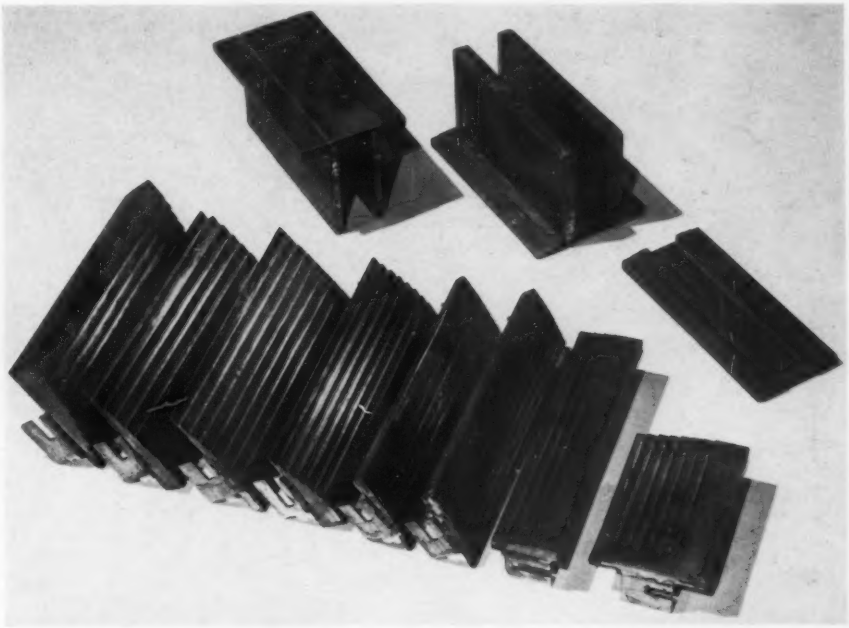

FIG. 4*A*. Set of wedge filters made of lead either covering the whole width of the portal or only half of it using the thicker half of the wedge. Wedge filters have been made to produce skewnesses of 30°–45°–60° of the isodose curves. The wedges seen in the upper part of the figures are used in the split portals for the treatment of patients with cancer of the cervix.

the shutters makes the end of the collimating device bulky. In a variety of settings, for instance in the head and neck area, parts of the body (the shoulders in this instance) prevent the use of short collimator-skin distances. The penumbra consequently is undesirably large, especially for small field therapy. In addition, shorter source-skin distances (SSD) have advantages in the treatment of tumors which are not too deeply located.

A combination of interchangeable cones and a light localizer gives a minimum penumbra with preserved flexibility (Fig. 2*A*). The cones were designed for not more than 3 per cent transmission outside the

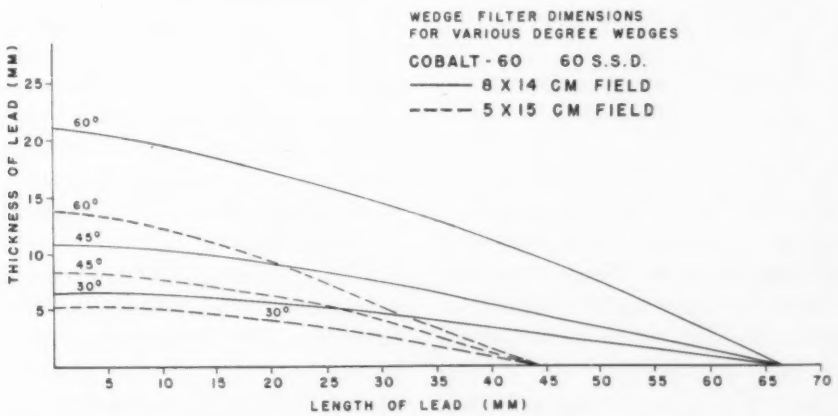

FIG. 4*B*. Graph showing dimensions of wedge filters for the short axes of 15 by 5 cm. and 14 by 8 cm. fields at 60 cm. SSD. When using a brass base for rigidity, 1/16 inch brass was considered equivalent to 1.2 mm. lead. The wedges are mounted on the lower end of the collimators, that is at 46 cm. from the source. Half-wedges are constructed from the thicker halves of the above wedges.

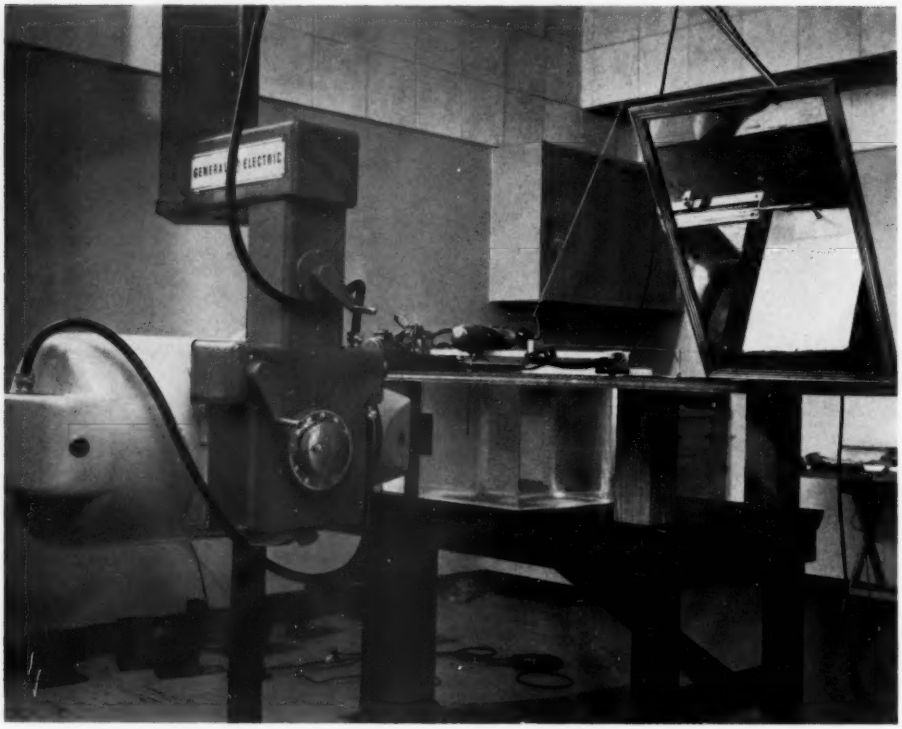

FIG. 5. Photograph of the physical set-up for measurement of isodose curves. The water phantom is 1 cubic foot, and the beam enters through a 1 mm. thick lucite window. The recorder uses a cylindrical anthracene crystal, 3 mm. in diameter by 6 mm. in length. The crystal is surrounded by a hard rubber cap of 0.25 mm. thickness, and mounted at the end of a polished aluminum tube. The photomultiplier tube is surrounded by lead to reduce the effect of scattered radiation. The ionization can be measured to a minimum depth of 4 mm. Once the gear is mounted it takes about one hour to run a set of isodose curves. This short time permits the study of a great variety of cones, source-skin distance effect on penumbra, effect of addition of umbrella-type diaphragms, wedge filters, special screenings, etc.

geometrical field. At 50 cm. source-skin distance the isodose curves are practically flat to within 1 cm. of the 10 per cent curve (Fig. 6*B*). The mucositis in the oral cavity or pharynx has been very sharply defined showing the steep gradient in the penumbra region.

BEAM FROM THE COBALT UNIT

A typical calibration chart is shown in Figure 3*B* in terms of maximum dose rates which vary slightly with field size. The charts are used for two month periods before being corrected for decay of the source. Isodose curves were obtained for a large number of these fields, both long and short axes as well as shaped fields, using an automatic isodose curve recorder[1] (Fig. 5). As seen from the chart (Fig. 3*B*) one can vary the source-skin distance and obtain various sizes of squares and rectangles, from 5 by 4 cm. at 50 cm. to 22 by 22 cm. at 80 cm. source-skin distance. Of course, since the source to end to cone distance is always 46 cm., with increasing source-skin distance, the geometrical penumbra increases proportionally with cone to skin distance. For the unit discussed in this report, the geometrical penumbra on the skin increases from 2 mm. at 50 cm. SSD to 1.5 cm. at 80 cm. SSD, and at 10 cm. depth from 0.7 cm. to 2 cm. At times this penumbra at large source-skin distances is found objectionable and can be blocked by means of auxiliary diaphragms to be described below. However, in order to block the penumbra it is essential that the penumbra be distinguishable from the geometrical field.

With a properly designed light localizer, this can be done simply by blocking the light beam to a slit along the edges of the cone. If electron filters are used this can be incorporated in the method of mounting the filters.[7] This requires that the light localizer be of high intensity and that the image of the light source in the reflecting mirror duplicate the radioactive source in size, shape, and position. If these conditions are met, the band of light passing through the slit will represent the geometrical penumbra. Actually one should find a dim inner band of light as well, due to reflection from the sides of the cone.

MEANS OF SHAPING THE BEAM

It has been the practice of this hospital to shape the beam of radiation in order to provide a volume distribution anatomically fitted to the disease. This is accomplished by anatomical fields and by altering the isodose distribution of the individual beams. The means are (a) auxiliary or umbrella diaphragms, (b) wedge filters, and (c) split fields. Isodose curves have been measured in all these varied conditions.

(a) *Auxiliary or Umbrella Diaphragms.* For treatment by external irradiation, the shape of the gamma, or roentgen-ray beam should be such as to match the areas to be treated. These areas are determined by the extent of the lesion and the anatomy of the region, and should not be restricted to simple configurations. To confine the beam to anatomical fields without having to construct an excessive number of collimators, corners and edges of the beam have been shielded by use of extra secondary diaphragms. Tungsten blocks, adjustable to any position, are used closer to the skin either to cut the penumbra in highly critical regions, or to shape fields to form trapezoids or triangles, or simply to cut corners and prevent unnecessary irradiation to regions not involved. Small tungsten blocks are used also for shielding parts of the body such as the eye.

A compromise must be made between shielding effectiveness and weight. A thickness of tungsten of 2.5 cm. which absorbs more than 90 per cent of the beam is a practical compromise. Greater thicknesses become unwieldy, and the increase of absorption is too small to make it worth while. The 2.5 cm. thick tungsten blocks have been found light enough to permit ease in positioning and can be attached to the Cobalt-60 unit by means of metal rods. The extra diaphragms are used in conjunction with that cone which best fits the treatment area.

The central axis per cent depth dose from a Cobalt-60 unit varies slightly with field size for areas greater than 25 cm.[2] Hence the difference in depth dose between the open and blocked fields is usually small. However, if the central section of the beam is blocked, a significant change in depth dose can result. Measurements were made to show the effect of eye shielding, blocking the geometrical penumbra, and blocking 2 cm. of the geometrical beam. The results of these measurements (Fig. 6*A*) justified the use of the diaphragms.

The use of an umbrella diaphragm to minimize the penumbra is important on the common sides of adjacent portals. With a 200–400 kv. beam the band of overdosage resulting from adjacent portals is not as wide nor as high as with the Cobalt-60 beam. This band can occupy up to two-thirds of the total area for small portals with the Cobalt-60 unit. Severe reactions and complications could arise, for instance in the treatment of tonsillar tumors where the upper field covers the primary and carotid nodes and the lower field the rest of the jugular chain. The arytenoids as well as a section of the spinal cord would be in the region of overdose. For the treatment of deep-seated tumors, separation can be calculated to avoid overdosage of the structures located above. For tumors which are located under the skin or a few centimeters below the skin, there is no way to avoid the overdosage of the deeper structures without having a cold spot on the tumor itself. In actual practice it is im-

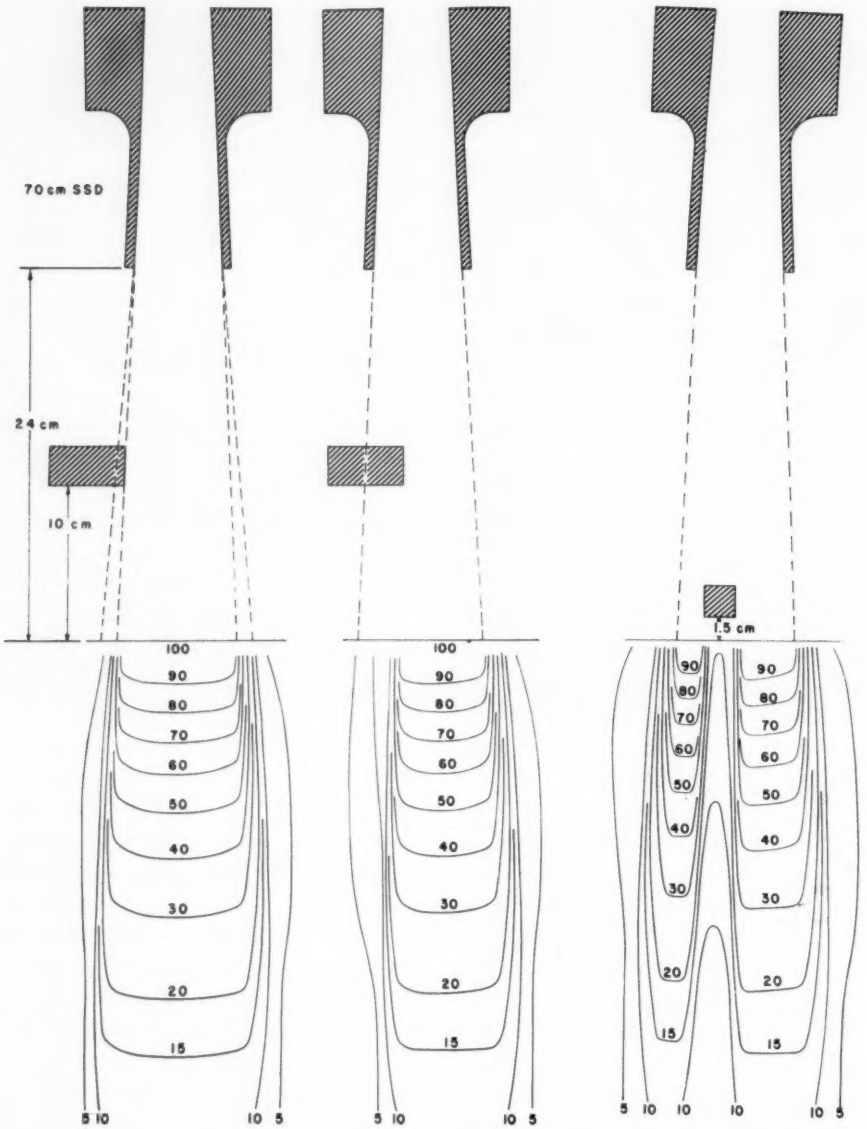

FIG. 6*A*. Isodose curves with 2.5 cm. tungsten block covering the geometrical penumbra on one side. The curves were measured with 24 cm. from end of cone to surface of phantom (70 cm. SSD). The tungsten block was located 10 cm. from the phantom surface with a 1 mm. brass sheet on the skin side to absorb secondary electrons from the block. One notes the sharpness of the beam on the covered side in contradistinction to the uncovered side. This difference would be greater at 80 cm. SSD and less at 60 cm. SSD.

Isodose curves with 2.5 cm. tungsten block covering 2 cm. of the geometrical field. This thickness of tungsten absorbs about 90 per cent of the beam with a sharp cut off. The 5 per cent and 10 per cent isodose curves are not significantly affected by transmission through the block.

Isodose curves with 2 by 2 by 5 cm. long tungsten eye shield located 1.5 cm. from the phantom surface. As predicted by the half-value layer of tungsten, 80 per cent of the beam is absorbed. There is practically no side-scatter. The screening is more efficient than in the 200 kv. range where the side-scatter reached the covered area.

possible to eliminate under or over dosage and one must avoid using adjacent portals if vital structures are located in the vicinity of the adjacent sides (Fig. 6*C*).

(b) *Wedge Filters*. In addition to a flexible collimating device, and the delivery of

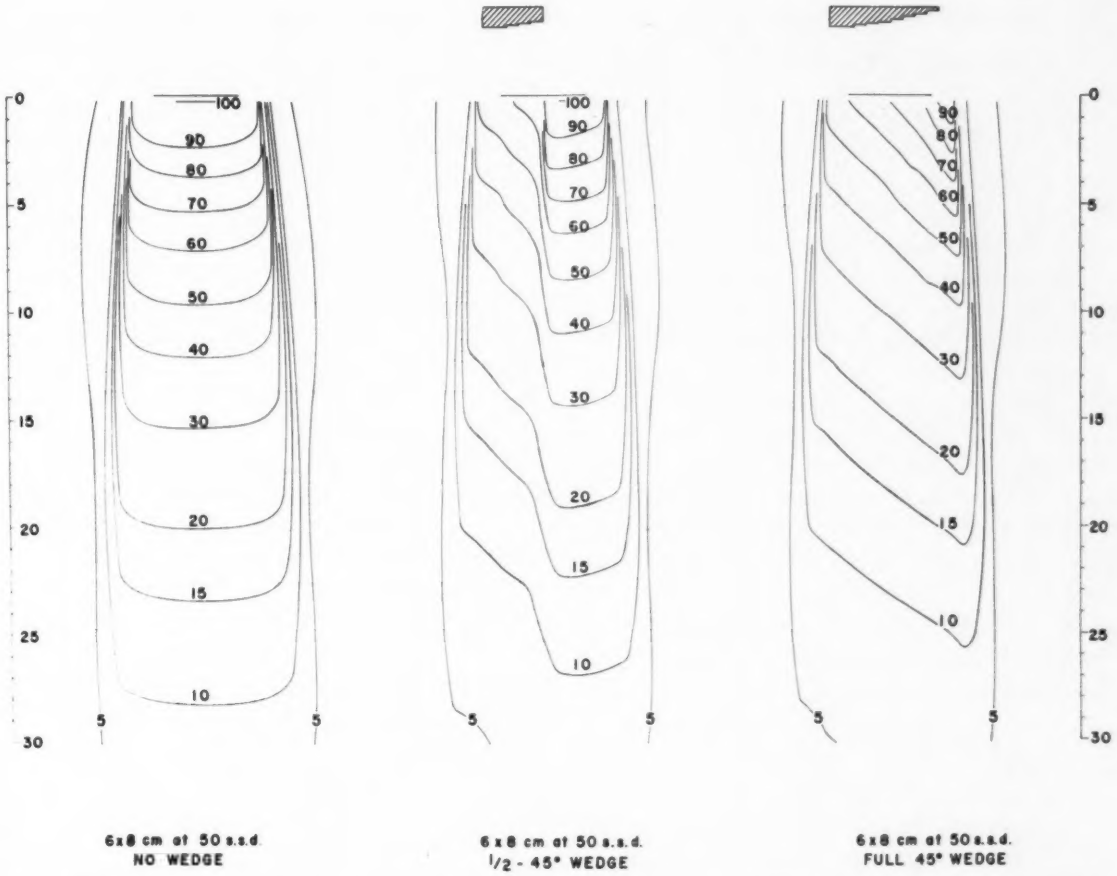

FIG. 6*B*. Isodose curves taken without wedge, with a 45° wedge covering half the field, and with a 45° wedge covering the whole field. The sloping effect on the curve in the covered part of the half 45° wedge can be put to good use in a number of instances.

unequal given doses in the multiple field technique, wedge filters help to produce volume distributions which provide an almost ideal shaping for certain tumors. Within the geometrical field, open field isodose curves from a Cobalt-60 unit approximate a line perpendicular to the central axis. Isodose curves with slopes of 30°, 45°, or 60° to this line are useful in multiple field techniques, depending upon the angle of the converging portals and the depth of the volumes to be irradiated. In addition to wedges covering the whole width of the portal, wedges covering half of the portal give, at times, a better volume distribution.

For Cobalt-60 units, it is possible to calculate the required dimensions of a wedge filter with a fair degree of accuracy (Fig. 4*B*). The wedge filters designed for this unit were calculated by a technique based on the open field isodose distributions for the cone under consideration. Broad beam half-value layers of the materials making up the filters were used. For a given wedge filter, an average of nine to ten steps was chosen. Since wedges constructed from lead alone were not found to be practical for everyday clinical use, a 1/16 inch brass base was added for rigidity, the brass base being included in the calculations. Although the final wedges could have been made without steps, the steps were retained because of ease in construction (Fig. 4*A*). Half wedges were constructed using the thicker halves of the full wedges.

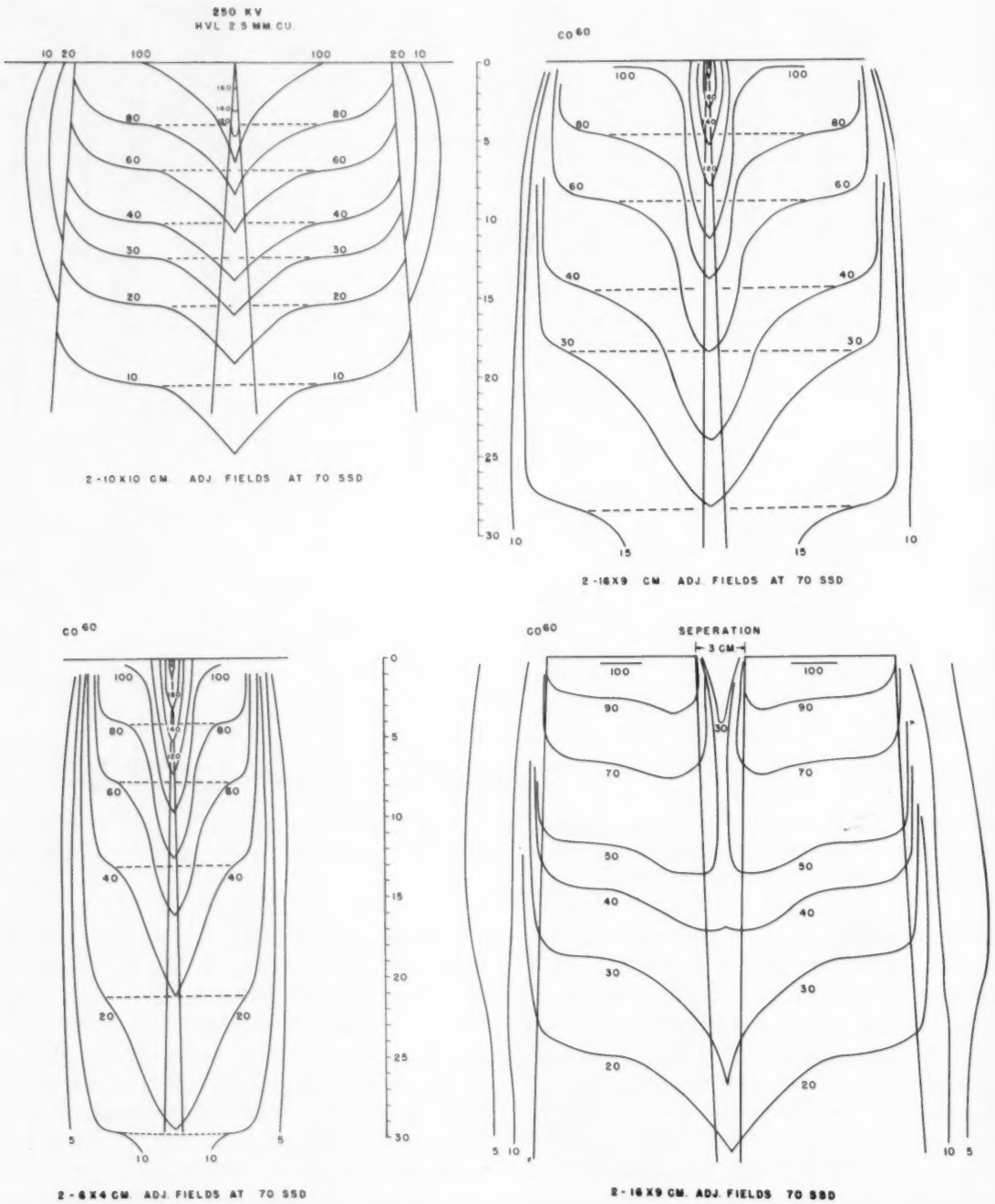

FIG. 6C. Comparison of the compounding of the isodose curves of two adjacent portals: (1) half-value layer 2.5 mm. Cu at 70 cm. SSD, 10 cm. wide; (2) Cobalt-60, 70 cm. SSD, 9 cm. wide; (3) Cobalt-60, 70 cm. SSD, 4 cm. wide; (4) Cobalt-60, 70 cm. SSD, 9 cm. wide with 3 cm. separation between adjacent sides.

It is to be noted that the width of the band of overdose is wider and the overdose greater with the Cobalt-60 beam. The dose is almost doubled on a width of 3–5 cm. The zone of significant increase occupies almost two-thirds of the total area of the small portals.

By separating the portals one can get rid of the overdosage but a gap appears at the more superficial levels. For instance, if one is treating nodes in the neck there is no way to avoid marked overdose on the spinal cord and/or arytenoids without creating a cold spot on the metastatic nodes themselves.

Isodose measurments were made for all wedge filters with typical results as shown in Figure 6*B*. At times the wedging of only one-half or some other fraction of the width of the portal is a more useful procedure than narrowing the portal. Vital structures, such as the spinal cord, can be spared without endangering anatomical accuracy. The central axis depth doses measured with the recorder are within 4 per cent of calculated values and the slopes within 3° of calculated values. When measuring isodose distributions of a wedged field, the 100 per cent point was taken as that of the open field. This was done to simplify the treatment chart as only open field dose rates are then needed.

(c) *Split Fields*. For treatment of carcinoma of the cervix, a compression attachment with an adjustable lead block is used which fits the collimator for a 14 by 14 cm. field at 60 cm. SSD. The beam is split into two separate beams of relative widths depending upon the position of the block. The block is of such thickness, about 6 cm., as to reduce the radiation intensity below the block to about 5 per cent of the maximum dose delivered to the two fields. Adaptors fit over the lead block to increase the shielded area between the two fields (split width). Wedge filters were constructed for use with these split fields. The filters are mounted on the splitting bock producing a 45° slope over 2 cm. of either one or both of the fields. The isodose curves show a fast but smooth rise in the wedged regions which helps to compensate for the fall-off of dose around radium systems (Fig. 6, Part I).

ACCESSORIES

A pointer device, attachable to the unit in the same manner as the auxiliary diaphragm support rods, is used routinely for measurement of the source-skin distance. The device consists of a light metal rod graduated in centimeter intervals with an offset lower end. The lower end holds a rubber tip which is always located at the center of the field.

Compression cones used for treatment of gynecological cancers, are shown in Figure 3*A*. The compression ends are made of brass mesh to reduce secondary electron emission. Given doses of 4,000 r have been delivered in five weeks to opposing 14 by 14 cm. split portals (the portals on each side of the split being 14 by 5 or 6 cm.) over the front and back of the pelvis with only faint erythema.

For localization of areas treated with the Cobalt-60 unit (Fig. 2*B*) medical roentgen film in a regular (lead screen on the patient's side) cardboard cassette are exposed and developed as for ordinary diagnostic procedures. Taking into consideration the source-film distance and the r/min. of the unit, exposure times can be determined for various thicknesses of the body. We have found that about 1 r to the film gives the best definition. When significant, the given dose required for this exposure is included in the treatment dose.

SUMMARY

A Cobalt-60 unit can be designed and equipped to fulfill the requirements of clinical radiotherapy. The beam can be shaped to fit with stationary portals the volumes determined by the anatomy and the behavior of cancers.

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We wish to acknowledge, too, the advice and help of Dr. E. Dale Trout, Consulting Radiation Physicist, X-ray Department, General Electric Company. The manufacturing of a telecobalt therapy unit of almost unlimited clinical flexibility would not have been possible without his help and that of the staff of mechanical engineers.

We wish to acknowledge, further, the assistance of the Carboloy Company in producing large pieces of tungsten alloy for the purpose of having a small compact unit.

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SIMULTANEOUS MULTIPLE PULMONARY ANGIOLAMINAGRAPHY*†

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THE normal roentgen image of the hilus and the lungs is made up mainly of the respiratory circulation, pulmonary artery and veins, and of the broncho-alveolar air. Participating minimally in the structure are the nutritive circulation, bronchial arteries and veins, the lymphatic vessels and the nerves. The changes in the quantitative proportion between the vessels and the air are responsible for the changed roentgen picture of the chest.

The tetralogy of Fallot with the paucity of respiratory circulation and Eisenmenger's complex with enlargement and engorgement of the pulmonary arteries are examples clearly illustrating the importance of the respiratory circulation in determining the roentgen picture of the lung. Therefore a pathological condition of the lung is evidenced by a change in the vascular shadow. Such a change may occur either directly, through increased or reduced filling of the vessels, or indirectly, through absent, diminished or increased quantity of the bronchopulmonary air. In the majority of cases there is a combination of direct and indirect causes and they often merge.

Increased filling of the vessels occurs in hyperemia and congestion. In such conditions, often combined, the vascular structure of the whole lung appears more pronounced than normal; the vessels are wider than usual. Hyperemia may occur locally in acute inflammatory conditions of the lung and in cases in which the intrapulmonary pressure is locally reduced, or it may appear in the whole lung.

Reduction or disappearance of the vascular structure occurs in pulmonary embolism, peripherally to the embolus, because the vessels are not normally filled with blood or they are obliterated. Disappearance of the vessels is also observed in the segment, lobe or entire lung due to increased intrapulmonary pressure. If the alveoli lose their air content by infiltration, exudation or resorption of the gases, an opacity appears. The vessels can no longer be distinguished from the alveoli since there is no difference in density and no contrast.

The opacity of the lung field takes on an appearance corresponding to the stage and degree of infiltration or atelectasis. Obliteration of the vascular shadow occurs either when a part of the lung is destroyed, for example when cavity develops, or when the pulmonary pressure is greatly augmented locally so that the finer vessels are completely compressed and emptied of blood. These conditions cause local rarefactions of small or large size without discernible vascular structure.

To diagnose correctly a grossly rarefying or opacifying pulmonary lesion, it is necessary to determine clearly the nature of the change in the lung field. Therefore we must in the first place establish whether it is a question of a primary change in the filling of the vessels or whether it is a matter of secondary alteration due to disappearance, decrease or increase of the bronchopulmonary air content. Further, we must determine carefully the extent of the change and its connection with the bronchi and the vessels. The shape of the abnormality should be stated in three dimensions. For this purpose we can use stereoscopic roentgenography or laminagraphy.

Often, however, these methods do not permit a full evaluation of the status of the bronchi and of the vessels of the diseased region. In such instances it is necessary to employ bronchography and pneumoangiog-

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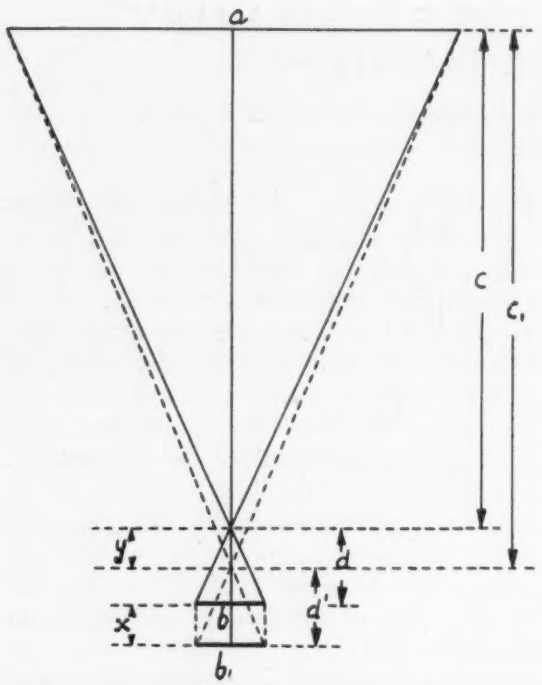

FIG. 1. Diagrammatic representation of the principle of simultaneous multiple laminagraphy.

raphy, especially in stereoscopic views.

The roentgen study of the behavior of the vessels has always been useful for normal and pathologic observations. This is chiefly true for the lung, which is mainly a vascular organ in structure and function. Angiopneumography, by showing the increased vascular markings, permits a good view of the anatomy and enables study of the physiology of the pulmonary arteries and veins. In this respect it represents a definite progress, but, although demonstrating the whole pulmonary circulation, it still constitutes a particular phase of the examination if standard roentgenography is used. A more precise study of the behavior of the vessels in and around the lesion can be obtained by employing a combination of angiopneumography and simultaneous multiple laminagraphy.

METHOD

In 1948 de Abreu created the basis of simultaneous multiple laminagraphy. In Figure 1 are shown the geometrical elements of this method. In the laminagrams with double emulsion the value of b changes in relation to a, that therefore does not modify the distance x (or the separation between the films). If the distance between tube and film is 150 cm. the relation $x:y$

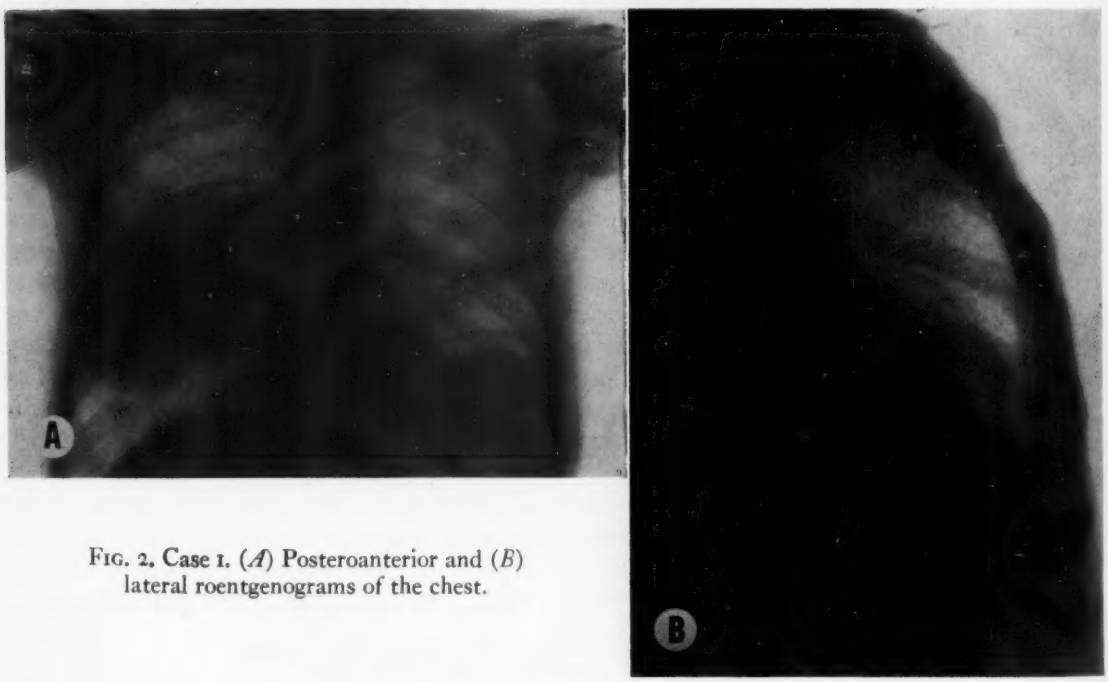

FIG. 2. Case 1. (*A*) Posteroanterior and (*B*) lateral roentgenograms of the chest.

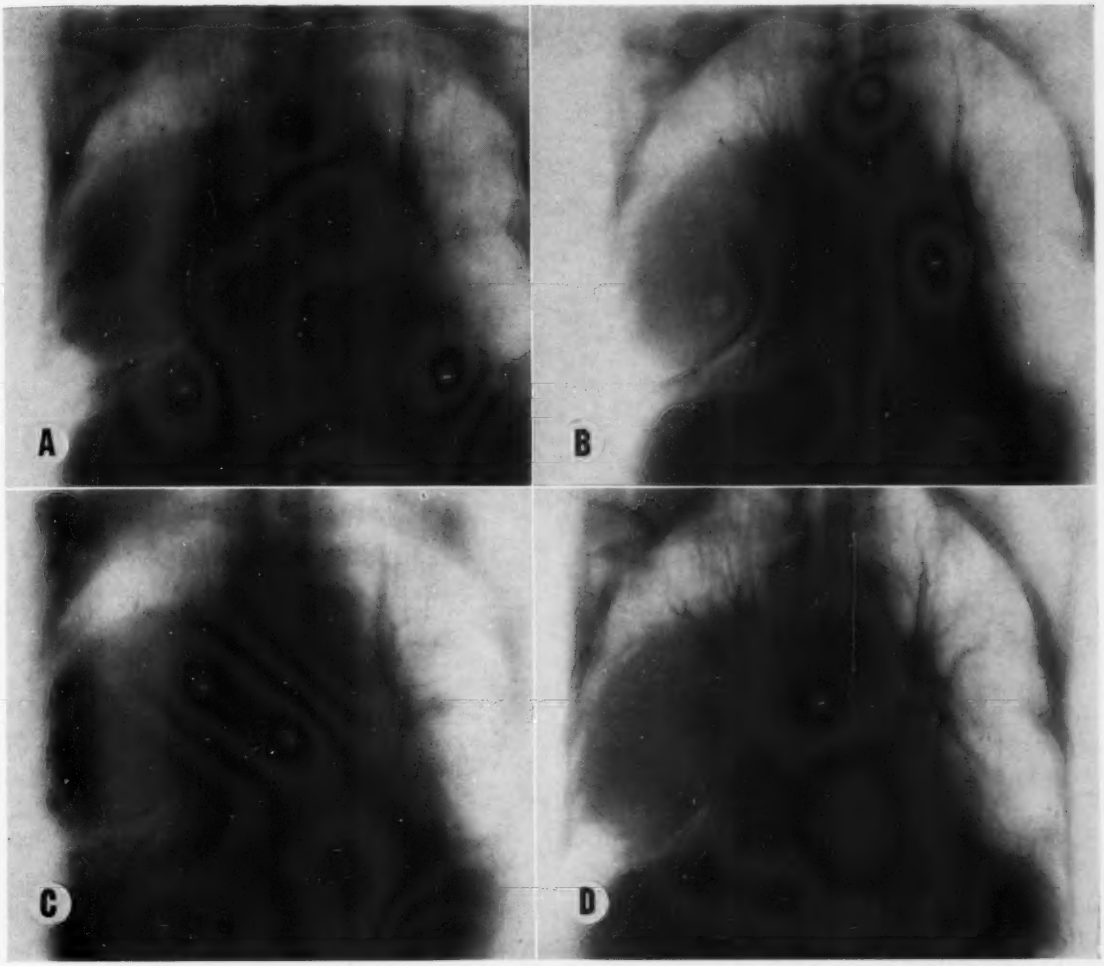

Fig. 3. Case 1. Simultaneous multiple angiolaminagrams at (*A*) 5, (*B*) 6, (*C*) 7 and (*D*) 8 cm. from the posterior aspect of the chest.

changes with the d' value between 1:1.538 and 1:1.034 respectively for values of $d=$ 20 cm. and $d=5$ cm. When $d=10$ cm., a more frequent occurrence, the relation is 1:1.071. In this case for separation of body sections of 1 cm. $(y-1)$ the distance between the films is $x=1.071$ cm. In other words, if more films are placed at different distances from each other, each film will be exposed by the body section proportionally to the distance between them. Usually 4–6 sections are sufficient with 1 cm. distance between each section. To have 4 sections with 1 cm. distance we put some foam rubber sheets of 1 cm. thickness between the films.

The films and the intensifying screens have the following arrangement:

(1) anterior sheet of screen, high speed film, black paper;
(2) anterior sheet of screen, normal speed film, posterior sheet of a normal screen;
(3) anterior sheet of a more sensitive screen, normal speed film, posterior sheet of screen;
(4) anterior sheet of an even more sensitive screen, high speed film, posterior sheet of screen.

Having tested the sensitivity of the patient to the contrast medium, using a high pressure injector, one injects into one of the veins of the elbow with a needle or into the superior vena cava, right atrium, right ventricle or pulmonary trunk with

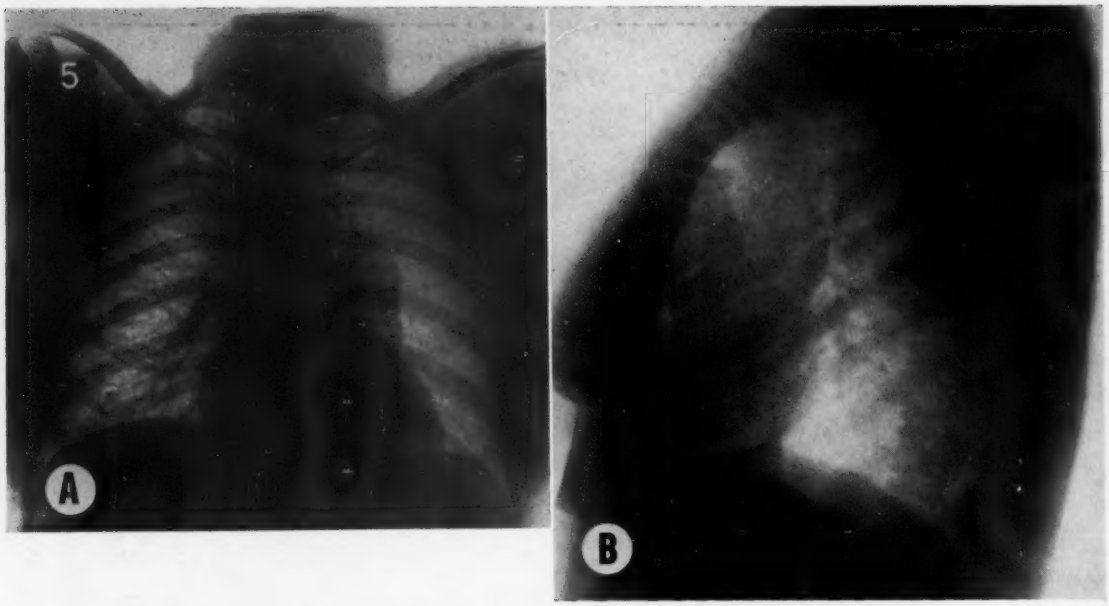

FIG. 4. Case II. (*A*) Posteroanterior and (*B*) lateral roentgenograms of the chest.

the aid of a cardiac catheter the necessary quantity of the opaque medium (40–60 cc. of 70 per cent ioduron).

As a result of a preliminary test with ether, the speed of the arm-to-lung circulation is known. This guides in determining the exact time for the laminagraphic exposure, usually three, five or eight seconds after the end of the injection.

The technical factors are the same as for conventional laminagraphy except that the voltage is increased with 10 to 15 kv. The exposure is 3/10 second and the oscillation of the laminagraph 20 degrees. The central ray is directed vertically to the lesion and the laminagraph is positioned in equatorial plane of the lesion as previously determined.

CASE REPORTS

CASE I. Male aged fifty-nine. For three years before visiting the clinic this patient had several episodes of left chest pain accompanied by high temperatures. These episodes were controlled by penicillin therapy. No tubercle bacilli were found in the sputum. At the end of one of these attacks the patient coughed up a large amount of salty fluid with some admixture of blood and decided to enter the hospital. A roentgenographic examination of the chest disclosed a cystic formation at the right base and another cystic formation at the left base (Fig. 2). A few days later the patient coughed up fragments of the membrane of an echinococcus cyst. The following day a combined angiographic and simultaneous multiple laminagraphic examination was performed, disclosing displacement of the pulmonary vessels by the pulmonary cysts. This was particularly evident in the film exposed at 8 cm. from the posterior aspect of the chest. This film also showed detachment of the cystic membrane (Fig. 3).

CASE II. Female, aged forty-one. Twenty years ago this patient was operated upon for a traumatic rupture of an echinococcus cyst of the liver. For one year before coming to this clinic the patient suffered left chest pain accompanied by headache, vertigo and fainting. No cough, no fever. These symptoms occurred three to four times a week. The recent roentgenographic examination disclosed a mass in the base of the anterior segment of the left upper lobe. A radiolucency shown by the lateral film indicated that this mass was an echinococcus cyst with the membrane partially detached (Fig. 4). Combined angiography and simultaneous multiple laminagraphy showed that there was displacement without alteration of the pulmonary vessels at the level of the mass (Fig. 5).

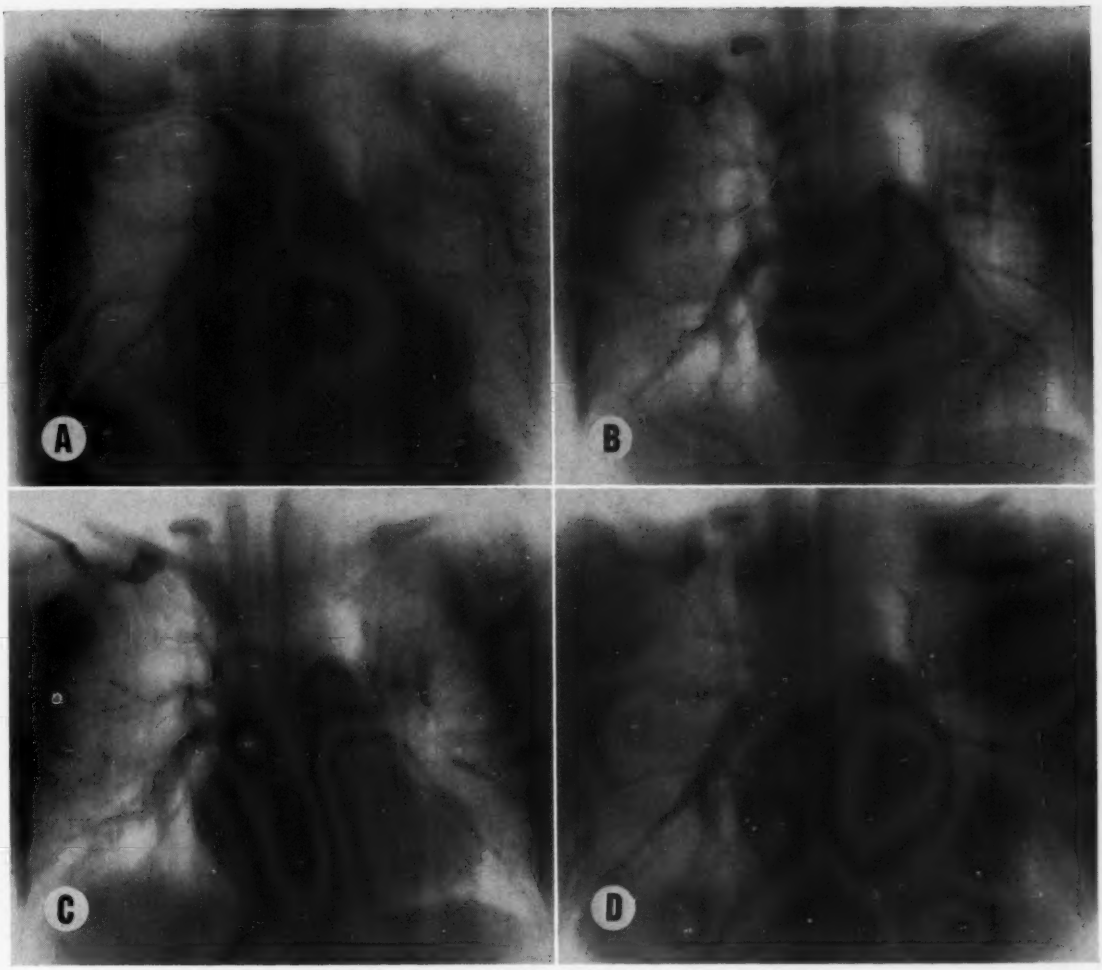

FIG. 5. Case II. Simultaneous multiple angiolaminagrams at (*A*) 9, (*B*) 10, (*C*) 11 and (*D*) 12 cm. from the posterior aspect of the chest.

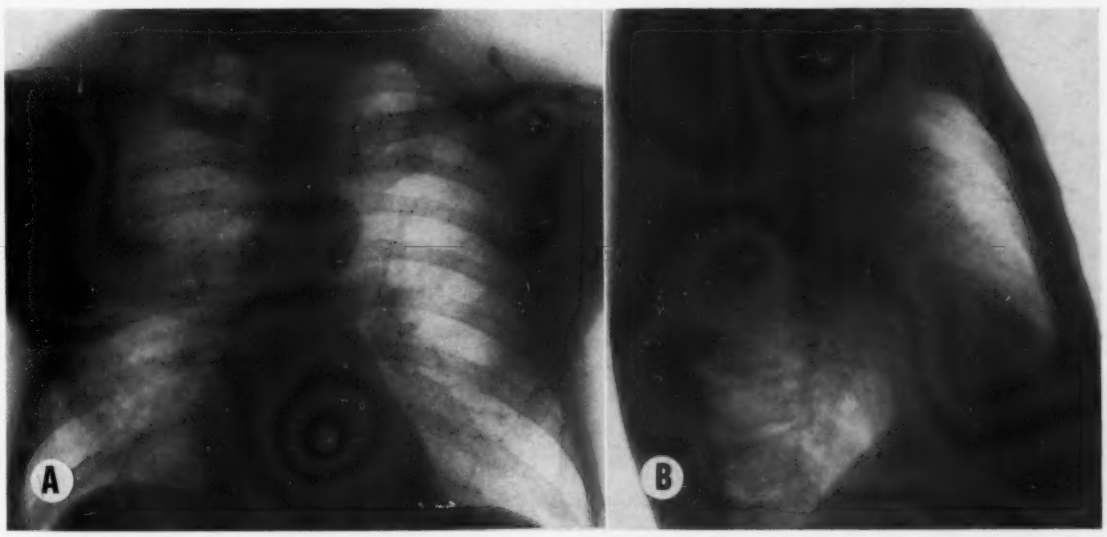

FIG. 6. Case III. (*A*) Posteroanterior and (*B*) lateral roentgenograms of the chest.

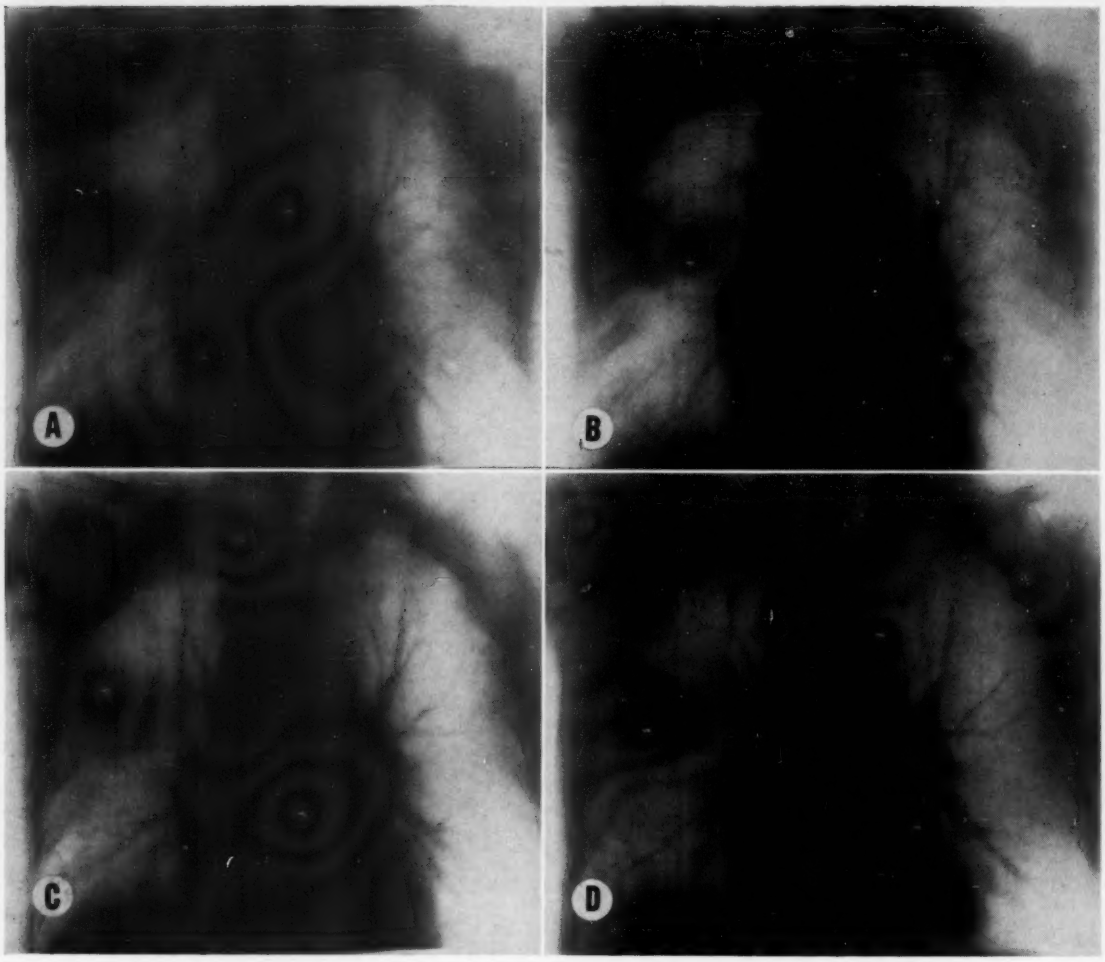

FIG. 7. Case III. Simultaneous multiple angiolaminagrams at (*A*) 5, (*B*) 6, (*C*) 7, and (*D*) 8 cm. from the posterior aspect of the chest.

CASE III. Male, aged forty-seven. For six months before coming to the clinic this patient had an episode of chills, fever, malaise and painful respiration. This acute condition was cleared by penicillin therapy, but after his partial recovery the patient began to cough up foul-smelling secretions. A roentgenographic examination disclosed an abscess cavity in the lateral and posterior portion of the right lower lobe with thickening of the near-by interlobar fissure (Fig. 6). Combined angiography and simultaneous multiple laminagraphy showed the appearance of the pulmonary vessels about the abscess (Fig. 7).

CASE IV. Male, aged thirty-five. About a year before coming to this clinic the patient became ill with chills, high fever, headache and general malaise. No cough.

Under aureomycin therapy the patient gradually improved and became afebrile, but recently he coughed up a small amount of blood-tinged sputum. A roentgenographic examination disclosed an opacity in the lateral and anterior segments of the right upper lobe with some cavitary images (Fig. 8). Angiography combined with simultaneous multiple laminagraphy showed irregularity of the upper branches of the pulmonary artery with reduction of their caliber (Fig. 9). This finding suggested the presence of a chronic inflammatory process. This was proved at surgery.

CASE V. Adult male. About a year before his first visit this patient had an attack of chills and high fever which subsided after penicillin

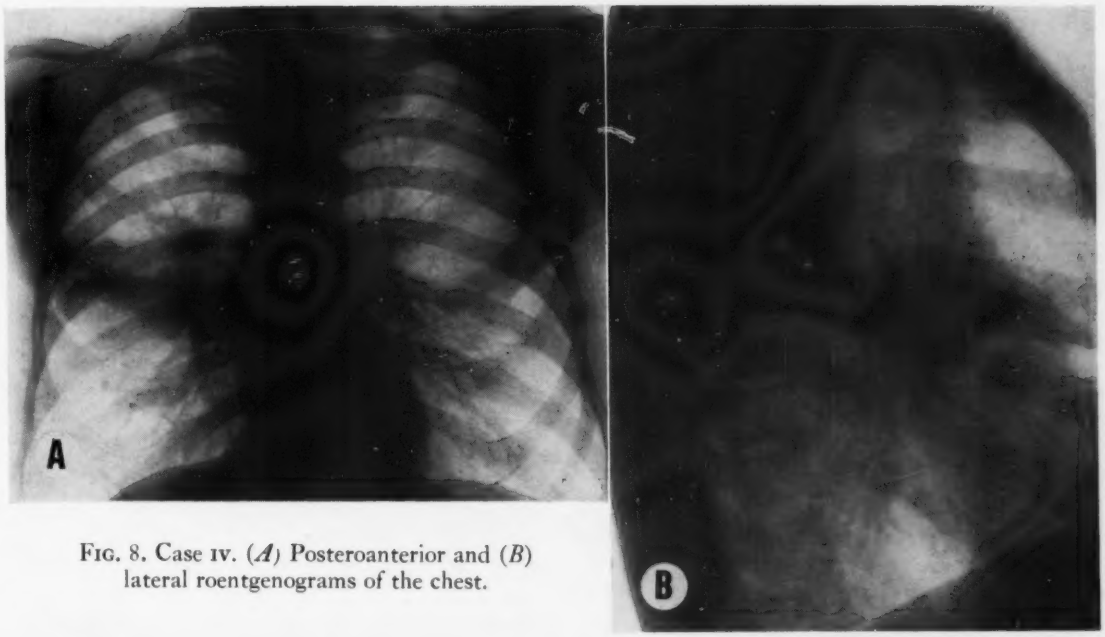

FIG. 8. Case IV. (*A*) Posteroanterior and (*B*) lateral roentgenograms of the chest.

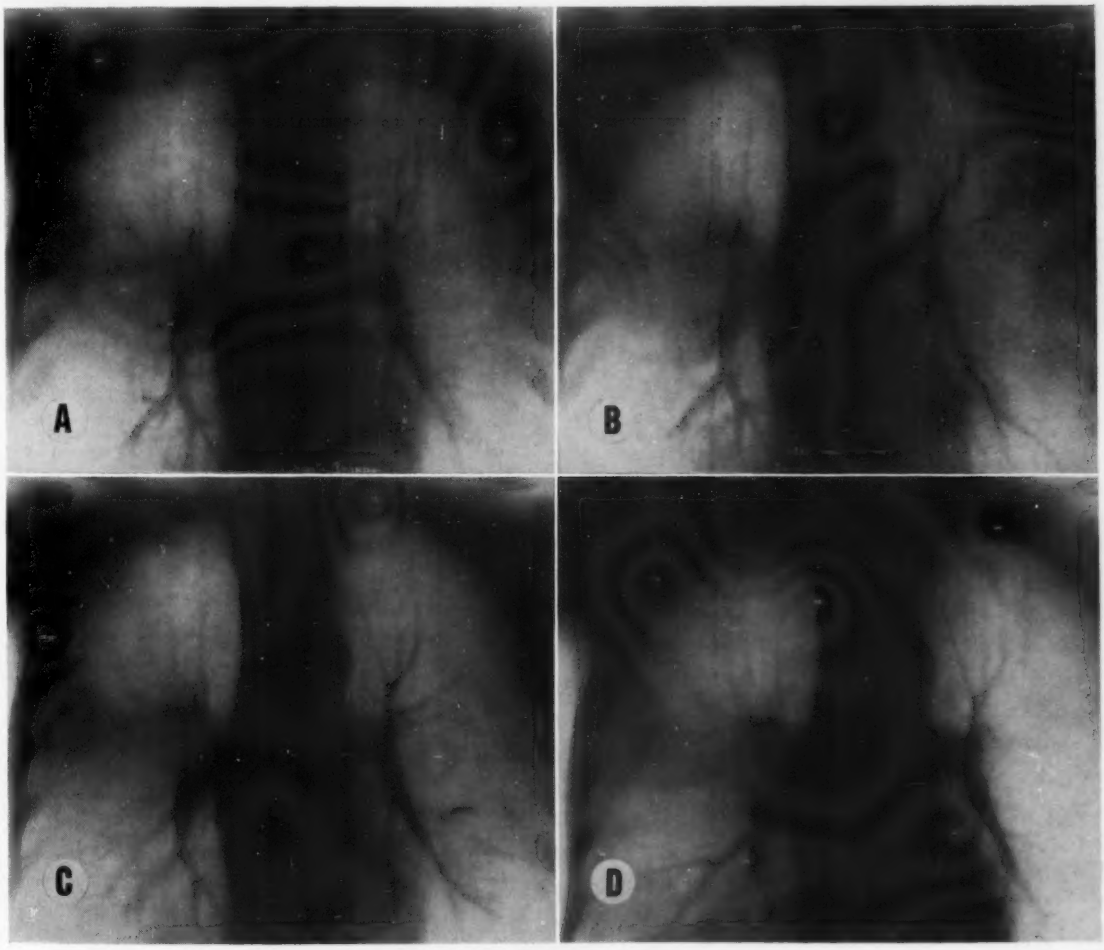

FIG. 9. Case IV. Simultaneous multiple angiolaminagrams at (*A*) 8, (*B*) 9, (*C*) 10 and (*D*) 11 cm. from the posterior aspect of the chest.

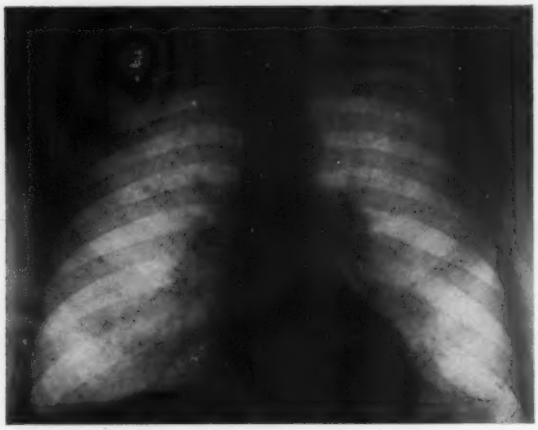

FIG. 10. Case V. Posteroanterior roentgenogram of the chest.

therapy. Six months after this attack he had a similar episode following which a roentgenographic examination disclosed a lung abscess. Later films taken at our clinic showed an opacity of the left base with multiple areas of radiolucency probably caused by bronchiectatic cavities. The left hilar shadow was enlarged (Fig. 10). Angiography combined with simultaneous multiple laminagraphy showed at 8 cm. a marked distortion of the vascular pattern of both lungs with intervening emphysematous bullae. At the left base the bronchiectatic cavities were surrounded by fine vascular channels (Fig. 11).

CASE VI. Male, aged fifty. This patient had an attack of bronchopneumonia six months before coming to this clinic and has not been well since then. At the present time he complains of joint pains, weight loss and blood-tinged sputum. A roentgenographic examination showed an upper right paramediastinal mass and another mass in the upper left lung field (Fig. 12). Angiography combined with simultaneous multiple laminagraphy showed at 9 cm. a marked encroachment of these masses upon the vascular channels of both upper lungs (Fig. 13). This suggested a neoplastic invasion

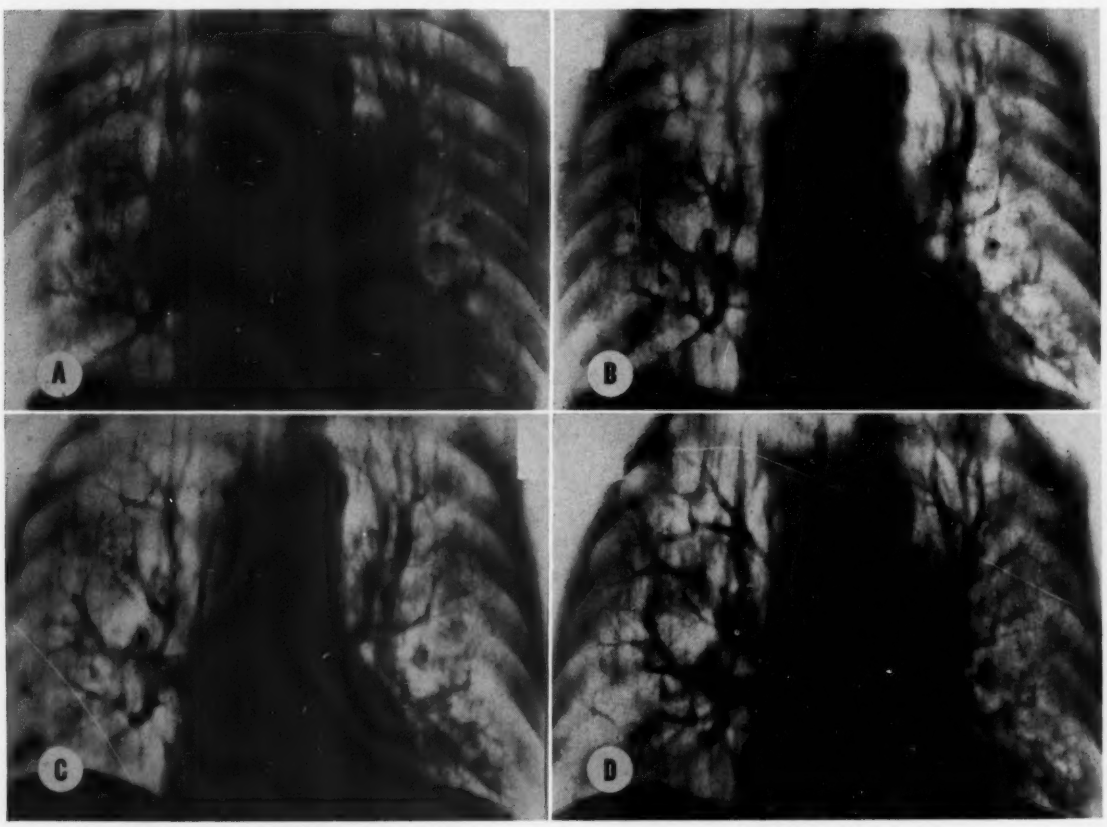

FIG. 11. Case V. Simultaneous multiple angiolaminagrams at (*A*) 6, (*B*) 7, (*C*) 8 and (*D*) 9 cm. from the posterior aspect of the chest.

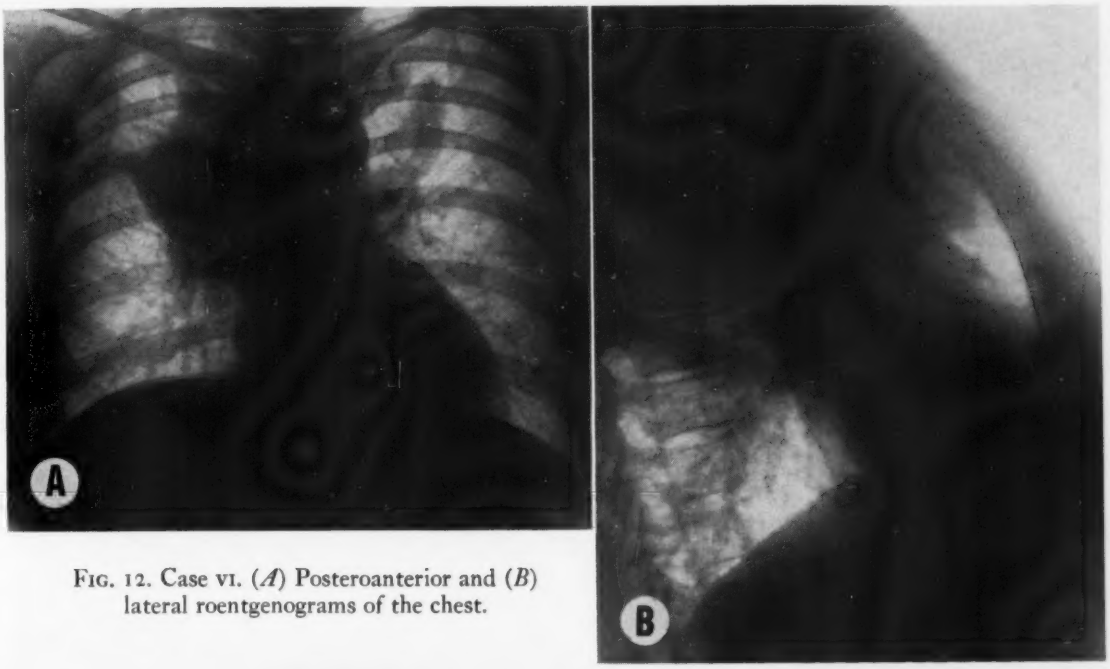

Fig. 12. Case vi. (*A*) Posteroanterior and (*B*) lateral roentgenograms of the chest.

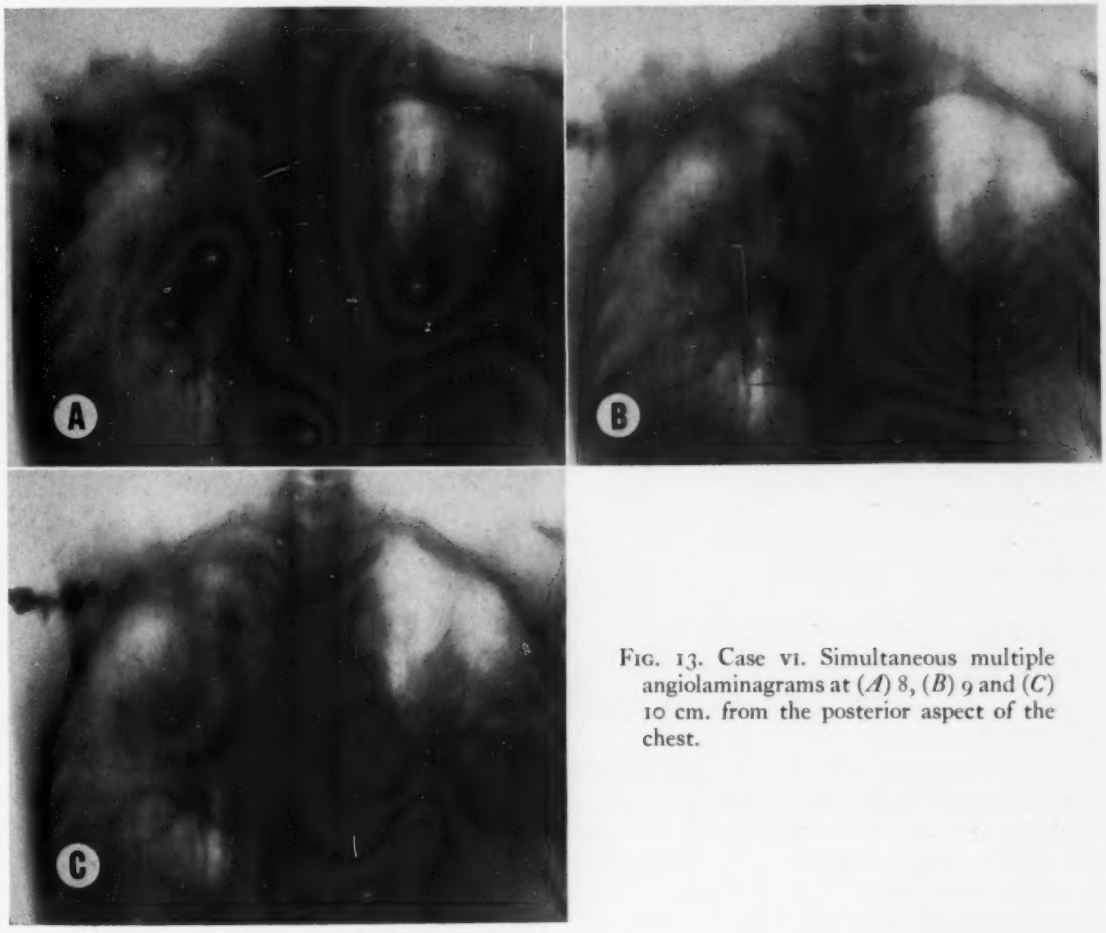

Fig. 13. Case vi. Simultaneous multiple angiolaminagrams at (*A*) 8, (*B*) 9 and (*C*) 10 cm. from the posterior aspect of the chest.

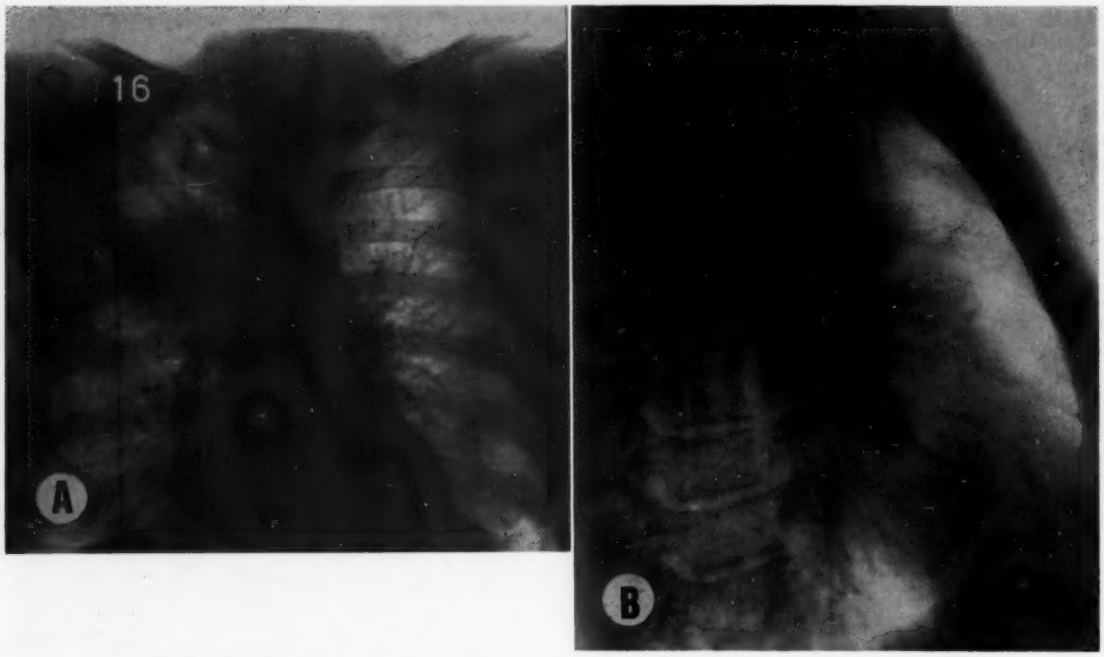

FIG. 14. Case VII. (*A*) Posteroanterior and (*B*) lateral roentgenograms of the chest.

of the vessels. This supposition was confirmed at surgery.

CASE VII. Male, aged forty-eight. The patient was well until three months before coming to this clinic, at which time he coughed up a small amount of blood. Roentgenographic examination of his chest disclosed a round mass in the lateral segment of the right upper lobe (Fig. 14). Angiography combined with simultaneous multiple laminagraphy showed at 9 cm. the almost complete obliteration of the right pulmonary artery with irregularity of the vessels at the periphery of the tumor and almost complete lack of vessels within the tumor itself (Fig. 15). At surgery this mass proved to be squamous cell carcinoma.

CONCLUSIONS

From the illustrative cases the following conclusions can be drawn, perhaps subject to future modifications.

(1) The echinococcus cyst, as a benign slowly expansive growth, produces only a displacement of the smaller and greater rami of the pulmonary artery; in the pulmonary field there are no functional changes (Cases I and II). When the cyst is infected or detached or collapsed, functional changes are revealed by arterial spasm.

(2) In suppurative processes we must distinguish recent suppurations from the older ones. If the suppuration lasts two to six months there may be hyperemia of the focus (Case III). If the suppuration has gone on for a longer time (Case IV) the vascular structure is very much diminished but it is impossible to state whether this is due to spasm alone or to thrombosis. There may be in remaining pulmonary segments a more or less generalized arterial spasm.

(3) In bronchiectasis the vascular network around the lesions is increased; some thick streaks, usually interpreted as "fibrosclerotic," are enlarged vessels or vascular ectasias (Case V). Sometimes there may be observed arterial spasm in the bronchiectatic area and hyperemia; sometimes arterial spasm occurs in the whole lung.

(4) In tumors the vascular structure is always altered. We can distinguish grossly two principal types of malignant lung tumors: (a) tumors with irregular and increased vascular circulation (Case VI); (b) avascular tumors (Case VII). In the first type the vessels are irregular, finer and more numerous than in normal, perhaps

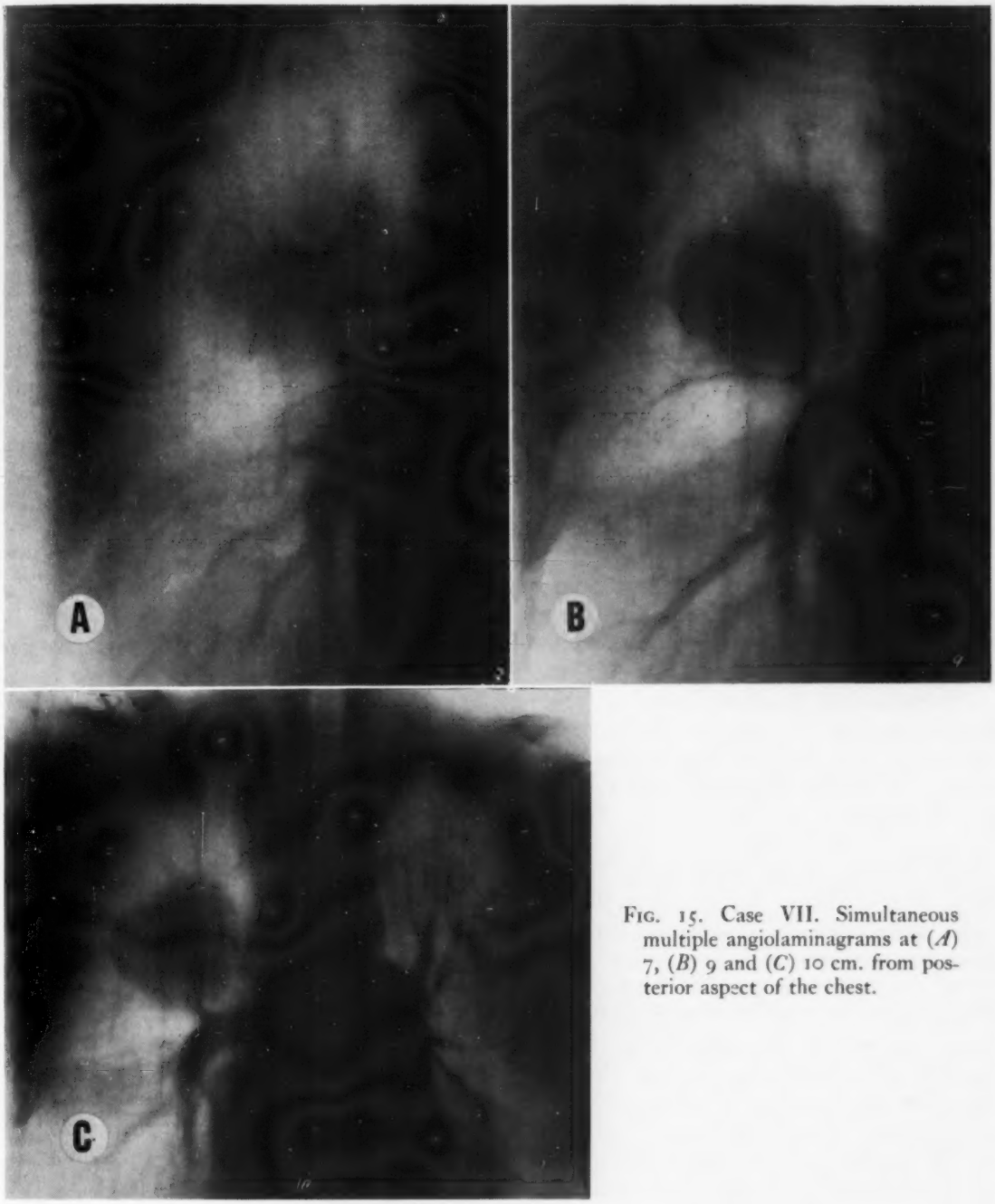

Fig. 15. Case VII. Simultaneous multiple angiolaminagrams at (*A*) 7, (*B*) 9 and (*C*) 10 cm. from posterior aspect of the chest.

with numerous shunts. In the second type there are irregular vascular markings peripheral to the growth; no vasular structure is discernible in the tumor. The first type is observed in undifferentiated carcinoma, the second type in malpighian (squamous cell) pulmonary tumors.

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A SIMPLE DEVICE FOR STEREOSCOPIC VIEWING OF FILMS

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THE simplest method of achieving stereoscopic film viewing is crossing one's eyes. Many cannot, or do not care to use this technique, and these persons will find the herein described device to be a substitute for ocular muscles (Fig. 1).

Basic materials. (1) A 2½ by 3 inch piece of front-surfaced mirror. (A piece of "transparent mirror" can be obtained from a plate-glass dealer for one dollar or less.) The back, or un-mirrored surface, should be covered with black paper or cardboard so that one cannot "see through" the mirror.

Accessory equipment. (1) Two standard viewboxes. (2) A stand or support of some kind to eliminate trembling of the hand-held mirror is desirable.

Procedure. (1) *Position of viewboxes*: Side-by-side, facing the examiner. (2) *Film manipulation*: The left-eye film is placed directly on the left viewbox; the right-eye film is *reversed* (right to left) on the right viewbox. Note top portion of diagram. (3) *Position of mirror*: As shown in the diagram (Fig. 1), the mirror is placed alongside the right side of the nose, equidistant from both films, in such position as to block direct viewing of the left film by the right eye. One looks at the left film with both eyes, using the mirror to superimpose the reflected right-film image seen by the right eye upon the left film.

Advantages. (1) Simplicity and economy. (2) Portability and saving of office space. (3) The viewer need not move from routine film-reading position. (4) The stereo image seen is not of reduced size, in contradistinction to the unaided, crossed-eye technique.

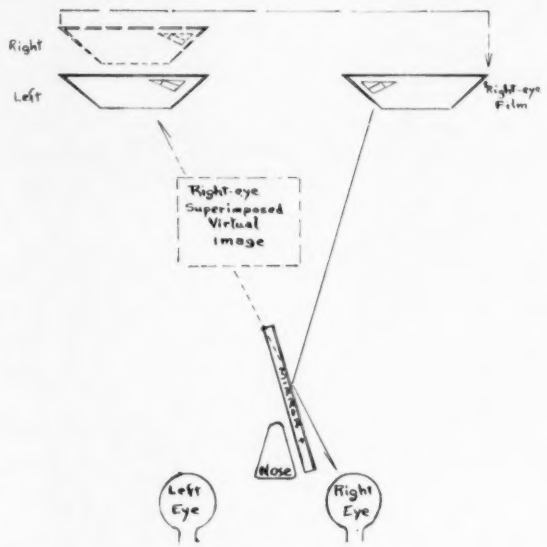

FIG. 1

Disadvantages. They are minor, and can be easily overcome. (1) Trembling of hand-held mirror: a simple support for the mirror can be fashioned. (2) Seeing the stereo image at a slight "angle": this can be overcome by turning the viewboxes slightly. (3) Images *not* of the same size: this is overcome by making sure the mirror is *equidistant from both films.*

DISCUSSION

The common, back-surfaced hand-bag mirror is not satisfactory because the layer of glass over the reflecting surface causes refraction of light at the acute angles of viewing employed, resulting in a blurred image. The front-surfaced mirror herein specified has no material over the reflecting surface, and so no image distortion occurs.

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STEREOFLUOROSCOPIC SPOT FILMS

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A STEREO pair of spot films can be made during fluoroscopy with the average equipment used by radiologists. Neither new equipment, equipment alteration, additional cost, change in fluoroscopic habits or procedures, prolongation of fluoroscopic time, increase of exposure to the patient nor additional instruction of technical personnel is entailed. Not infrequently the third dimension obtained saves time in that the additional information obtained allows conversion of the diagnostic consultation from an equivocal "there may be" to a definite "there is." Repeated examinations may thus be avoided.

The technique is limited to those fluoroscopic procedures wherein little or no physiological motion occurs, and where a compression device is not strictly necessary. It has proved to be useful in (1) barium enemas, (2) postoperative cholangiography, (3) bronchography and (4) myelography. It may be helpful in pneumoarthrography, sialography and sinus tract injections.

Technique. The technique to be described is the most practical compromise of several tried. Those discarded were: (1) *Rotating the patient through angle θ* (Fig. 1) while keeping both the roentgen-ray tube anode and spot film device stationary. Although this method more closely approaches ideal geometry, it proved to be relatively inconvenient because some patients simply could not be controlled with the finesse required in the short period of time available to make the two spot films. However, applying the above principle to routine, above-the-table, nonfluoroscopic, stereoroentgenography eliminates the absolute need for a stereo-shift device on the tube stand. This could be a considerable economy for radiologists who are just starting out in office practice. Ten degrees of rotation of the part will effect practical stereo films for the entire range of 36 to 72 inches target film distance. (2) *Moving the tube anode only*: this is too inconvenient mechanically and the direction of shift is limited to across-the-table. The technique finally chosen and described below does have geometric defects of academic interest, but the same defects are also inherent in the tube-shift method of stereoroentgenogra-

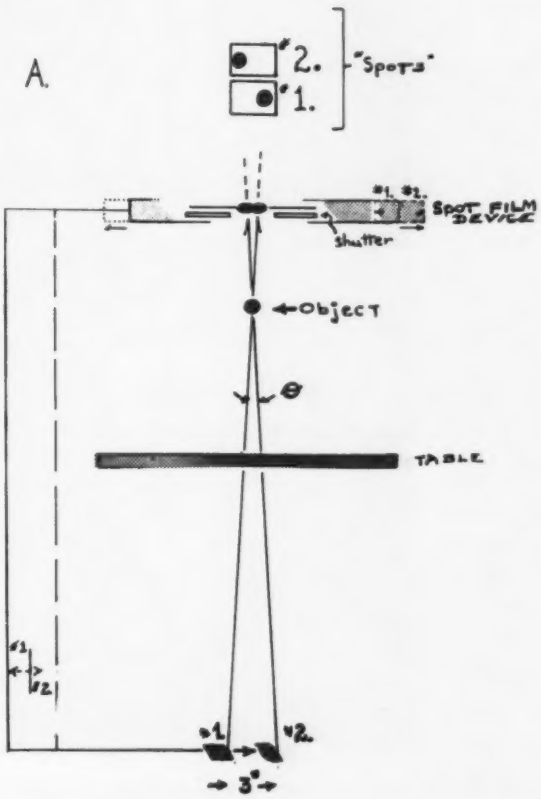

FIG. 1. With an average target-spot film distance of about 33 inches, a total anode shift of 3 inches (1.5 in. to either side of the center of the object) satisfies basic requirements for making stereo spot films. The films are viewed at about 30 inches. Smaller anode shifts can still result in serviceable depth perception, and other viewing distances can be quite satisfactory.

Note that the anatomical "object" is the only stationary component; the fluoroscopic carriage and the tube anode both shift, and this mechanical coupling is the prevalent fluoroscopic situation. Absolutely no addition to, or change of, existing equipment is necessary to obtain a pair of spot films which will stereo.

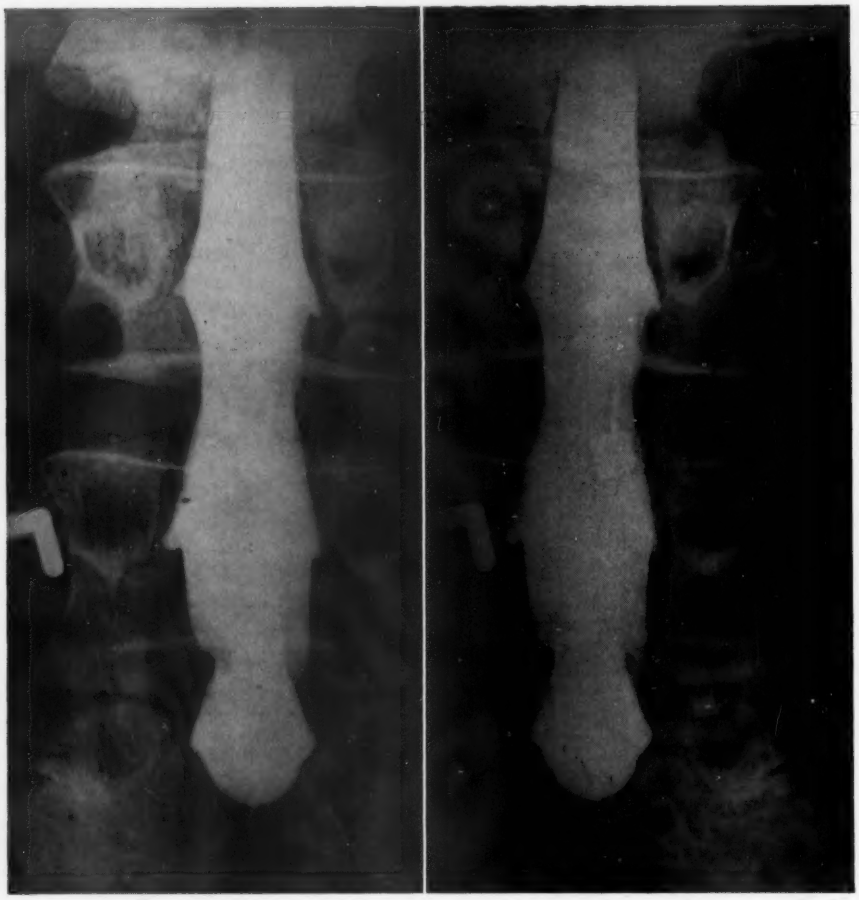

FIG. 2. *Fluoroscopic stereo spot films.* Note that little shift is necessary to either side of the midline. Stereo depth perception is excellent when viewing the films. Some idea may be obtained from this reproduction by using the "crossed-eye" technique. The latter viewing technique would suffice, without cutting up the film, if the spot films were side by side horizontally, or if the "spots" are one above the other and vertical shift were used to make them; otherwise the exposures must be separated for viewing by cutting the film.

phy routinely used especially if there is no associated tube angulation. The theoretical geometrical deficiencies of the system are outweighed by the practical results of the technique.

Making the stereo spot films. The patient is in routine fluoroscopic position for the particular examination. The size of the image on the fluoroscopic screen needed to cover the object to be "spotted" is made a trifle longer in the direction in which one desires to "shift." The fluoroscopic image of the object is brought close to one side of the field by shifting the carriage and the first spot is taken (Fig. 1, *A* 1). The film is returned to its protected position. With the patient still immobile and holding his breath, the entire fluoroscopic carriage is moved so that the object is now near the opposite edge of the same field and the second spot film is made (Fig. 1, *A* 2). The above procedure satisfies the basic requirements for making stereo spot films.

After processing the film is cut, separating the stereo pairs. They are then exam ined in the usual fashion.

Comment. The "shift" during fluoro scopy may be done either across the table, longitudinally, or obliquely in any direction, provided one views the films appropriately. The anatomy to be covered determines the number of stereo pairs of spots

obtainable per film. Automatic spot film devices are helpful but not necessary.

Possibilities of further technical developments. The technique does not work well with a compression device because shifting the carriage requires a shift in compression, and this causes alteration of the shape of the anatomical part. Compression and spot films in stereo would not be mutually exclusive if the roentgen tube anode could be *conveniently* shifted to get the two spot films, without shifting the spot film device or the patient; or, a more ideal method would be to have two separate roentgen tube focal spots which would be energized either simultaneously or in rapid succession, associated with some sort of device on the film carriage which would permit either simultaneous or rapid-sequence exposure of two separate areas of film. This would allow stereo spot films of viscera having rapid peristalsis, and a compression cone could be used.

Comments on clinical procedures. As presented the technique does not work well on distal stomach, duodenum or remainder of small bowel (except possibly terminal ileum) because of peristalsis. Gastric fundus and upper body lends itself pretty well if peristalsis is not too active and if the patient cooperates well in holding respiration.

One of the more valuable usages has proved to be with respect to barium enemas, and especially double contrast studies of sigmoid colon. The technique might well help to delineate a polyp in a diverticulitic, distorted sigmoid.

The aid offered in bronchography is considered quite valuable because spot films, even non-stereo, are frequently more informative than large films taken later because alveolar filling is avoided. The third dimension obtained with stereo spot films clarifies bronchial anatomy and pathology.

In myelography, the technique has not as yet proved to be a convincing addition to routine studies. In one instance a midline disk was seen on the stereo anteroposterior spot films which might have been missed on the routine, non-stereo spot films taken after fluoroscopy.

Application of the technique to postoperative cholangiography has been beneficial in that a more detailed evaluation is possible.

CONCLUSION

Spot films taken during fluoroscopy can be made to offer the advantage of stereo depth. This can be done with facility on unaltered equipment now in use.

The method described is *not* recommended where compression spot films are needed, or where motion cannot be controlled. It has proved to be of value in double contrast studies of the colon, in postoperative cholangiography, in bronchography, and in myelography; other possible uses and technical refinements are suggested.

It is not one's intention to overemphasize stereo, but there are areas of activity wherein the extra dimension is quite valuable. Spot filming done in stereo furthers the diagnostic armamentarium. Its greatest usefulness seems to be in areas which do not lend themselves easily to routine studies and complete diagnostic satisfaction.

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ACKNOWLEDGMENTS

The technical insight, practical aid and stimulation offered by Mr. Hubert J. Harrison, Technical Associate, has been of inestimable value in working out the technique described. It could not have been done without the kind cooperation of Sister M. Adelaide, Technical Supervisor of Diagnostic Roentgenology, St. John's Hospital, Tulsa, Oklahoma. The proofreading and text suggestions of Dr. Lucien M. Pascucci were invaluable.

ROENTGEN EXAMINATION OF OLD AND NEW TRAUMA OF THE SPINE WITH THE ULTRA-FINE FOCUS ROENTGEN TUBE*

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CONSIDERABLE work has been done in recent years on the enlargement of roentgenographic images to improve roentgen diagnostic accuracy. This work has been confined mostly to examination of the extremities and, more particularly, of the joints of the hands and feet.[3] However, Wood,[5] in a recent article, suggested the use of the ultrafine focus tube in the roentgen examination of the spine. We have since used this method in traumatic cases involving the dorsolumbar spine. It is our impression that the geometric enlargement of the vertebrae, using the fine focus tube, is of value in the differentiation between old and new trauma.

Two methods have been used for the enlargement of roentgenographic images, namely, the photographic and the geometric. The former consists of the production of a roentgenogram of normal size with the best possible definition and then an

* From the Department of Radiology, University of Louisville School of Medicine, Louisville, Kentucky.
Aided in part by a grant from the Kentucky State Medical Research Commission. Illustrations by the Department of Audio-Visual Education, University of Louisville.
The fine focus tube used was graciously furnished by Mr. W. E. Stevenson of the Machlett Laboratories, Springdale, Connecticut.

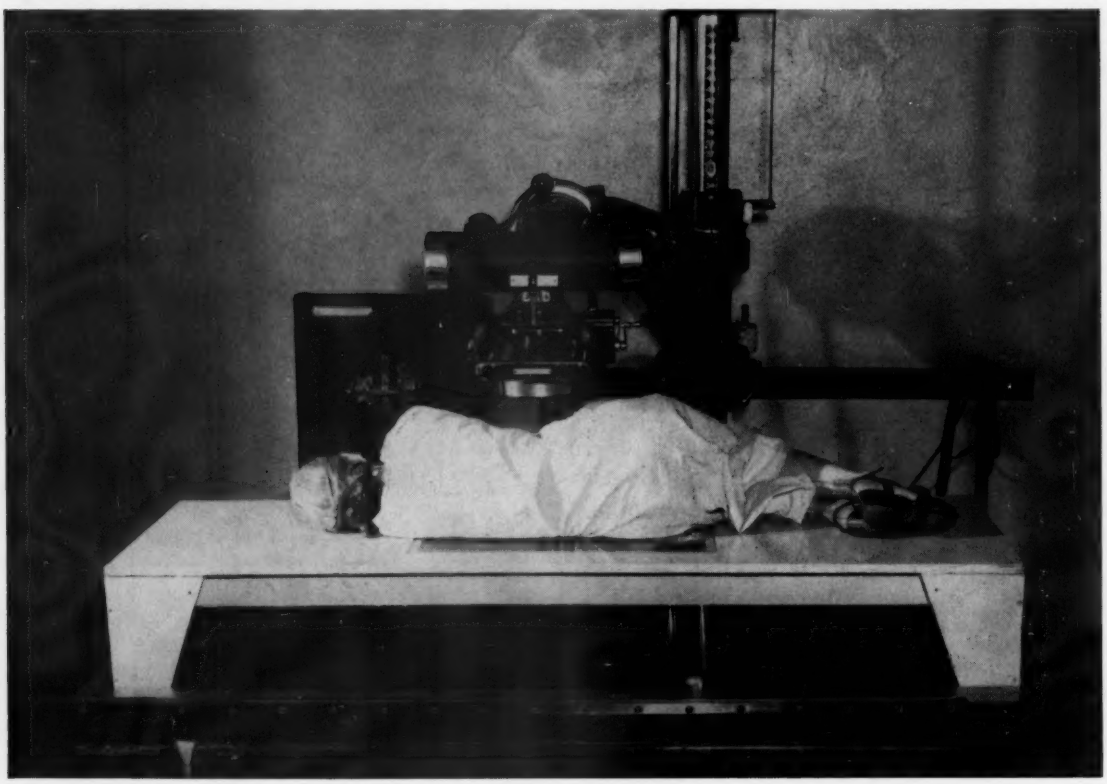

FIG. 1. Photograph of patient positioned for geometrically enlarged roentgenogram of lateral view of spine. Note the plywood false table placed on the regular roentgen table. The part to be examined is centered over the plastic window in the false top. No alterations of the present table or Bucky grid are needed.

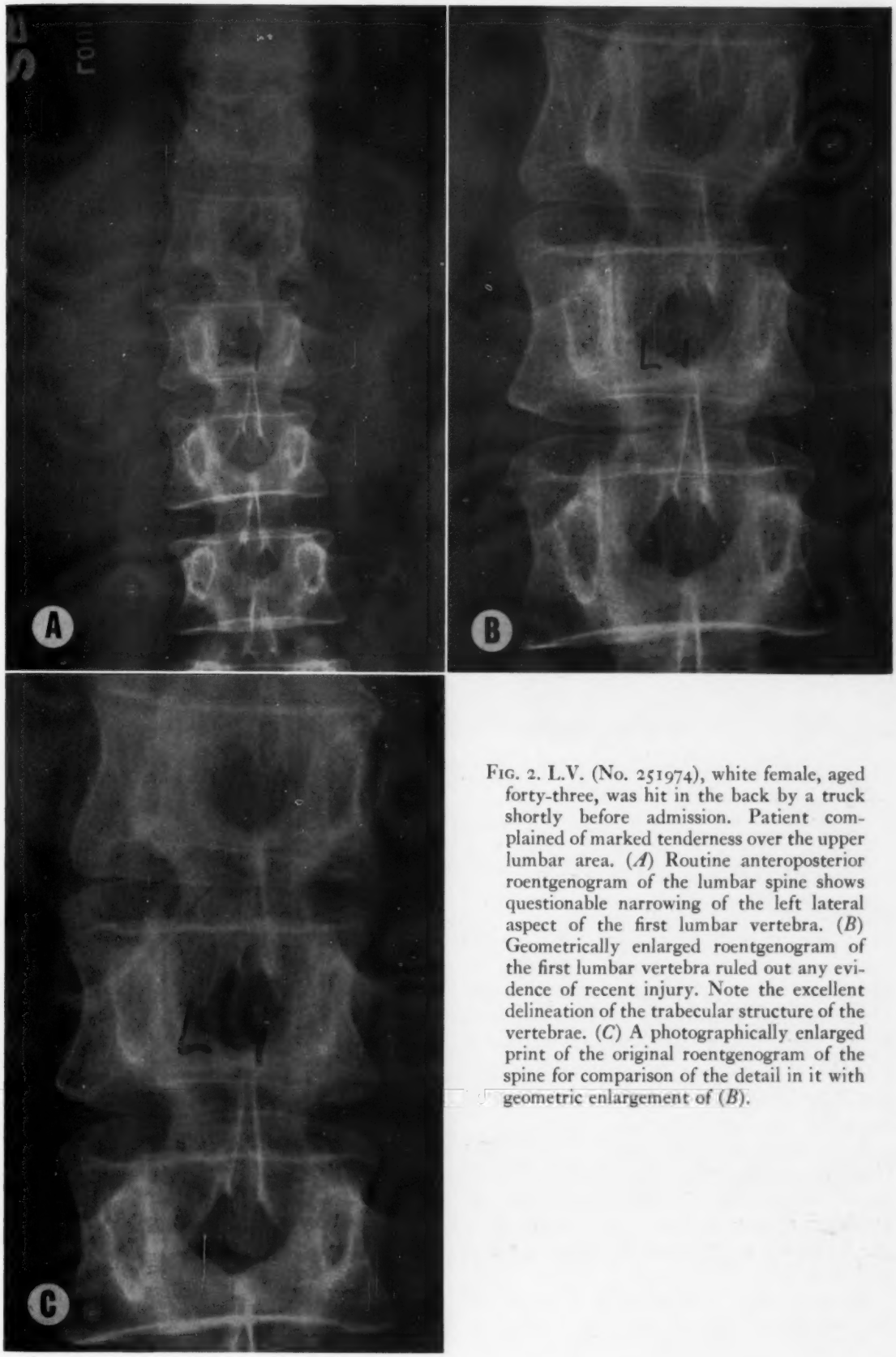

FIG. 2. L.V. (No. 251974), white female, aged forty-three, was hit in the back by a truck shortly before admission. Patient complained of marked tenderness over the upper lumbar area. (*A*) Routine anteroposterior roentgenogram of the lumbar spine shows questionable narrowing of the left lateral aspect of the first lumbar vertebra. (*B*) Geometrically enlarged roentgenogram of the first lumbar vertebra ruled out any evidence of recent injury. Note the excellent delineation of the trabecular structure of the vertebrae. (*C*) A photographically enlarged print of the original roentgenogram of the spine for comparison of the detail in it with geometric enlargement of (*B*).

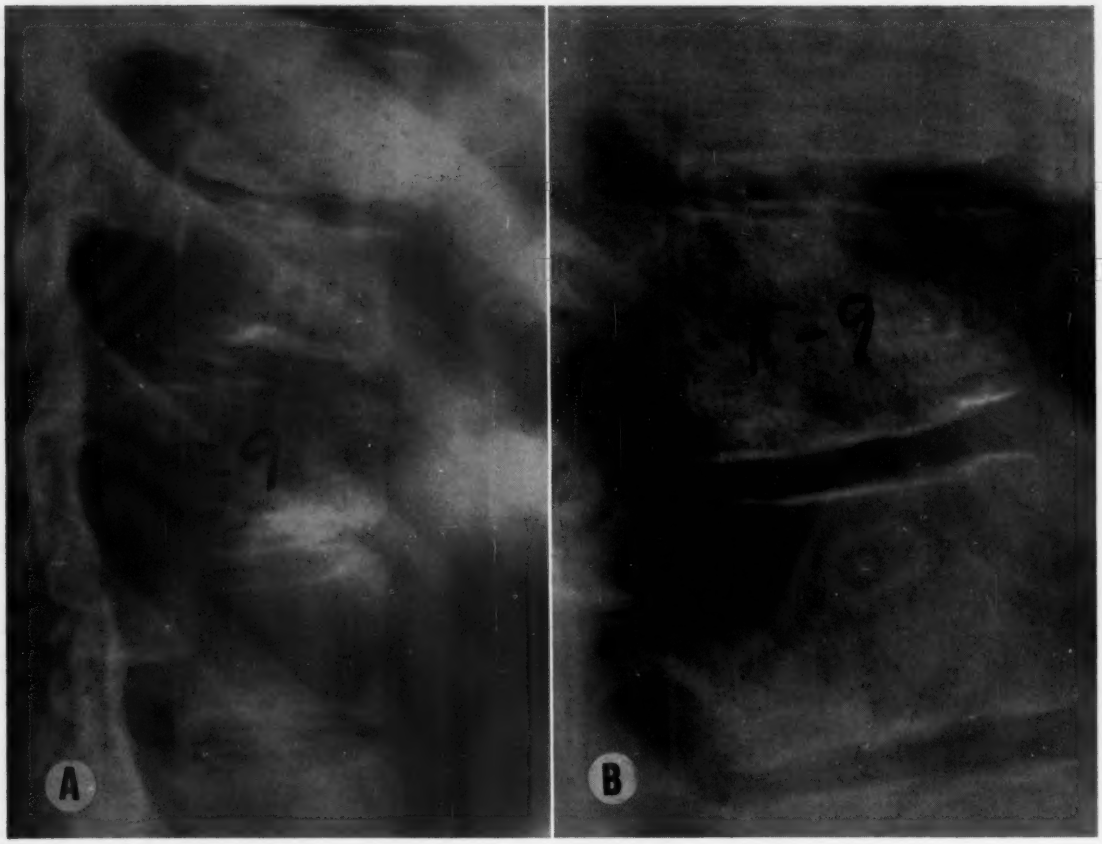

FIG. 3. R.L. (No. 233325), white male, aged nineteen, who fell out of a moving car two hours previous to admission. Physical examination revealed contusions and abrasions over the left lumbar area with tenderness (*A*) Routine lateral view of the 9th thoracic vertebra shows anterior wedging of the vertebral body. The age of the bone changes is questionable. (*B*) Geometrically enlarged lateral view of the 9th thoracic vertebra. The anterior edge of the vertebral body and the trabecular structure show no break in contour or impaction, indicating that the wedging of the body is not of recent origin.

enlargement is obtained photographically from the original film. This method has been used for many years. Wasson,[4] in 1922, was able to photographically enlarge a dental film two times its original size. Since then many workers have experimented with various techniques to obtain the finest type photographic enlargements possible.

Enlargements of 8 to 10 diameters have been obtained without appreciable loss of definition[1] if the roentgen examination is confined to small parts and certain rules are followed, such as using fine grain film and developer.

Photographic enlargement of standard size roentgenograms of thick parts, such as the spine, made with a 1 mm. focal spot, is not helpful because of the lack of detail in the original roentgenogram (Fig. 2). The fact that the vertebral structures cannot be brought close to the film results in blurring due to the penumbra effect of the larger focal spot size.

The geometric method of enlargement makes use of the divergence of the beam of roentgen rays. If the target-object distance is appreciably less than the target-film distance then an enlarged image of the object will be produced. The degree of enlargement is the ratio between the target-film distance and the target-object distance. Wasson,[4] again in 1922, using a pinhole lead diaphragm, was able to pro-

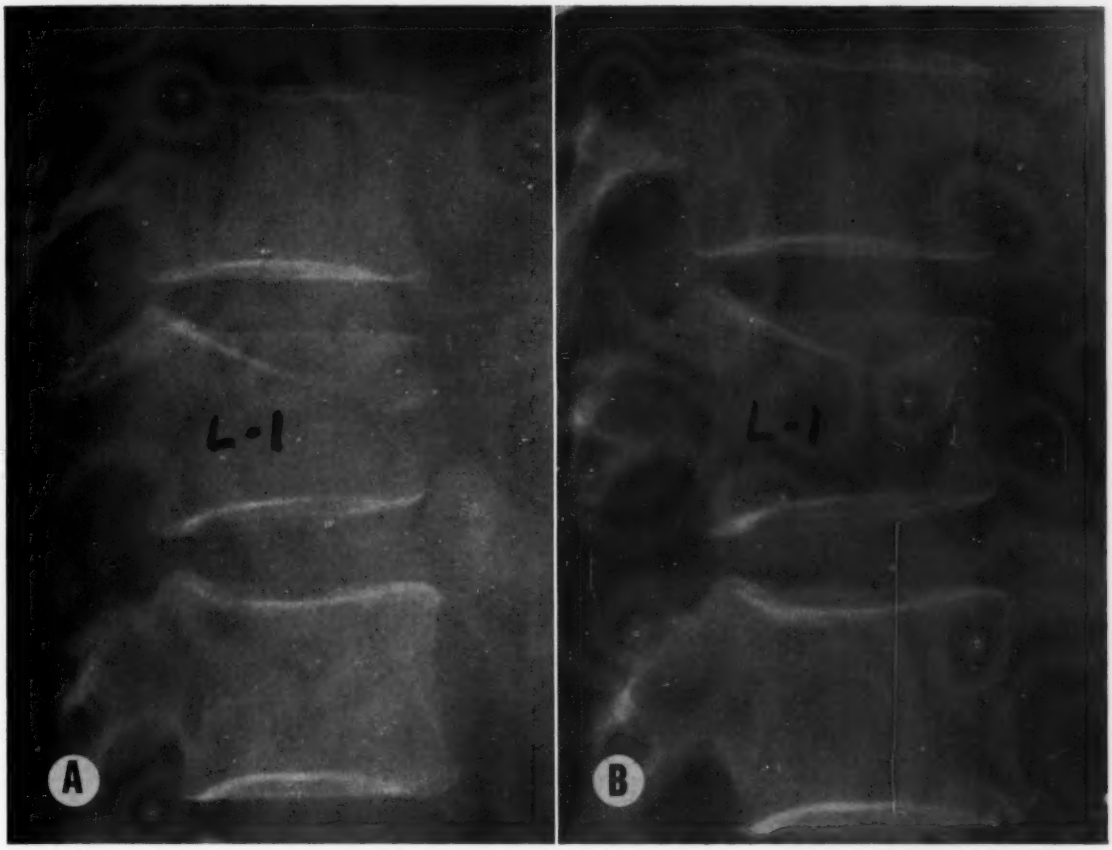

Fig. 4. E.W.G. (No. 231198), a white male, aged fifty, who hurt his back while pushing a car. On physical examination there was noted tenderness over the lumbar vertebra with marked muscle spasm. (*A*) A routine lateral view of the first lumbar vertebra showed irregularity of the anterior margin and superior plate of the first lumbar vertebra. The age of the bone changes cannot be determined from this film due to the lack of trabecular detail. (*B*) A geometrically enlarged lateral view of the first lumbar vertebra which reveals the cortex, both anteriorly and superiorly, of the vertebral body to be intact, and that the trabeculae under these irregularities remain unchanged. These findings indicate no evidence of recent bone injury.

duce geometric enlargements of dried bones of the foot.

More recently, however, enlarged roentgenographic images of living patients have been obtained by using a roentgen tube having a focal spot of 0.3 mm.[5] An advantage of this technique is that geometric enlargement of a part reduces the relative blurring effects of the screen and film grain in proportion to the part size. That is, the larger the image of the part, the less effect the grain size will have on its detail. The increased part-film distance also results in less scattered radiation reaching the film, and therefore improves the contrast of the roentgenogram.[2] Because there is less scattered radiation one can use a higher kilovoltage and, therefore, fewer milliampere-seconds to achieve the same roentgenographic effect.

It is doubtful that the use of geometric enlargement is of any increased diagnostic value when examining small parts. This apparently accounts for the lack of enthusiasm in the past for this method.

At our institution, we are frequently confronted with the roentgen differentiation between old and new trauma involving the vertebral bodies. For a year and a half we have been using the fine focus tube for

roentgenography of immediate post-traumatic cases in which there was a question concerning the age of the bone changes in the thoracic and lumbar spine.

The technique used in our department consists of anteroposterior, lateral and oblique films of the desired part with approximately 42 inch target-film distance. The patient is placed on an elevated platform with a plastic window above the table top with the spine approximately half way between the tube and film (Fig. 1). In the lateral position the patient receives 7 to 9 roentgens, as measured with a Victoreen r meter on the skin.

In many of these cases this technique has been a definite aid in the differential diagnosis between old and new trauma. In several cases the fine focus tube prevented the use of body casts and other means of treatment. The patients were spared many hospital days. In a few instances this technique has been helpful in medicolegal cases by enabling the radiologist to arrive at a more definite opinion and, in connection with this, it is assumed that the use of large detailed films before a lay jury would be quite impressive. Representative cases are presented (Fig. 1–4).

A double focus rotating anode tube, such as the one we are using, should not impose any undue financial burden on a large roentgen department inasmuch as the 1.5 mm. focal spot can be used for routine roentgenography and the 0.3 mm. focal spot used only when these special procedures are desired.

SUMMARY

1. A review is given and comparison made of the photographic and geometric methods of enlargement of the roentgenographic image.

2. The advantages of the use of the geometric method of enlargement with the ultrafine focus tube in the spine are stated.

3. The ultrafine focus tube seems to aid in the differential diagnosis between old and new trauma of the spine.

4. This technique should prove to be helpful in medicolegal cases.

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A MULTIPLE PINHOLE CAMERA FOR ACCURATE CENTERING OF THE ROENTGEN-RAY TUBE IN ITS HOUSING*

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IN THERAPEUTIC roentgen apparatus the precise centering of the target of the roentgen tube with respect to the treatment cones is often neglected. The installation is accepted as done by the service men, and no check made on alignment. This is an important factor and should be given attention in any new equipment and in the replacement of tubes. An error in target location may produce a cut-off, that is, an area of low dosage at the edge of the field, and as a result the treatment area will not be as large as the radiotherapist assumes when using a particular treatment cone. This factor becomes especially important with a double diaphragm system, where a slight error in the target location will produce a comparatively large cut-off at the edge of the field.

A straightforward method of locating the target is to place a lead plate containing a single pinhole between the target and the film as shown in Figure 1 (a second pinhole may be desirable for orientation). Let F be the desired center position of the focus, F' is the actual position. (If the tube is properly centered F and F' coincide, or $FF'=0$). B' is the target image. P, the projection of F, is marked on the film. A pinhole through the cardboard folder, penetrating the film, will serve as a good mark. The error in target location is directly reflected on the film. By projecting the image onto lines parallel to the long and short axes of the tube, the error may be measured on the film, as indicated by XB' and YB', and then simply corrected for magnification. It must be remembered that the pinhole image and the direction of the shift are reversed.

The target height must be known. Any error in this value introduces an error into the result. For example, when using a 50 centimeter target-film distance, with the lead half-way between the target and the film, if the error in the assumed distance is 1 cm., the error in the measured FF' will be 4 per cent. This is negligible, however, when considering the distances involved in relation to the industrial tolerance of the equipment.

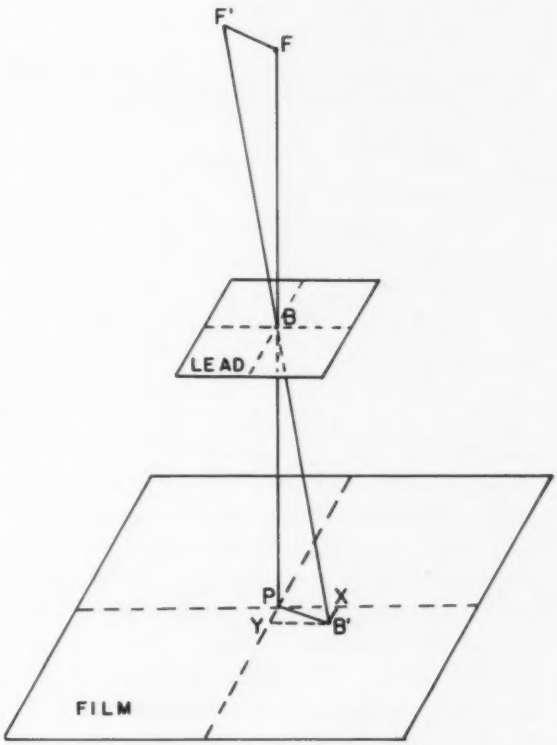

FIG. 1. Diagram for simple pinhole camera.

A completely rigid system is of great importance in this type of measurement. If facilities are available for producing a rigid, accurately aligned system of the above nature, the procedure is good because of its

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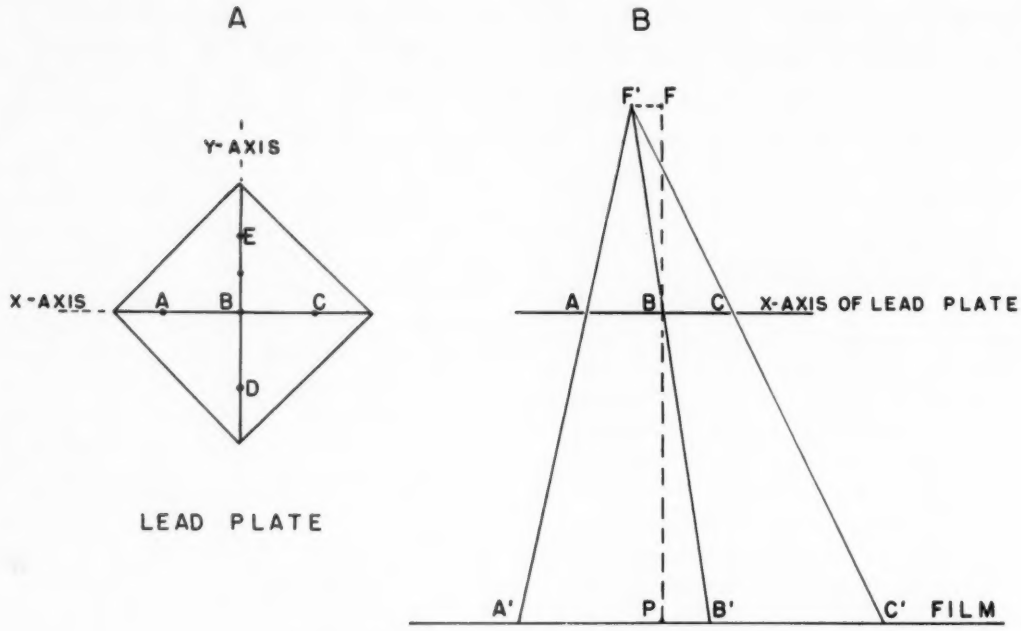


FIG. 2. Diagram for multiple pinhole camera.

simplicity. Variations of this method have been presented in the literature.[1,2] However, the crude pinhole cameras frequently employed do not possess adequate rigidity, results cannot be duplicated, and conclusions are equivocal.

A simple adaptation of the pinhole camera makes possible the accurate alignment of the target in two directions. This is accomplished by inserting a lead plate with six pinholes as shown in Figure 2*A* at the upper diaphragm of a large standard treatment cone. Pinhole distances should be chosen to suit the geometry of any particular case (Fig. 2*B*). The largest available cone will allow the greatest pinhole spacing and therefore greater accuracy. For a 15 by 15 cm. cone for example, a 50 cm. target-film distance and a 30 cm. lead-film distance, the four outer pinholes, which are equidistant from the center, should be at about 2 cm. from the central hole. The sixth pinhole (at 1 cm. from the center in this case) is used for orientation. The use of a lead-film distance greater than the target-lead distance is preferable so that the error in target location will be magnified. The lead plate may be designed so that it can be used successfully for several different roentgen-ray therapy machines. The lead must be accurately centered and rigidly fixed to the cone.

Diagonal crosshairs are placed at the bottom of the cone, which will be in contact with the film. The face of the cone is brought into contact with the film, absolutely parallel to it, with the center over a previously marked point. Again a pinhole through the cardboard folder, penetrating the film, will serve successfully. If the cone is not transparent, or if crosshairs are unfeasible for another reason, the four corners of the field must be indicated in some manner (pinholes through the film holder) and the diagonals drawn on the finished film to locate the center.

The port is lined up so that the two rows of pinholes (the diagonals) are parallel to the long and short axes of the tube. The exposure is then made.

Let A, B, C (Fig. 2*B*) be the pinholes along one diagonal, which will be called the x direction. A', B', C' are the target images, F is again the desired position of the focus, F' the actual position. P is the film center marking.

In the following derivation the geometric quantities are considered to be projected onto the plane determined by the x-axis and the line FB.

Consider the similar triangles $F'BC$ and $F'B'C'$. From these it can be seen that

$$\frac{F'B}{BC}=\frac{F'B+BB'}{B'C'} \tag{1}$$

then

$$F'B=\frac{BB'\times BC}{B'C'-BC} \tag{2}$$

From the similar triangles $FF'B$ and $PB'B$ we have

$$\frac{FF'}{F'B}=\frac{PB'}{BB'} \tag{3}$$

therefore

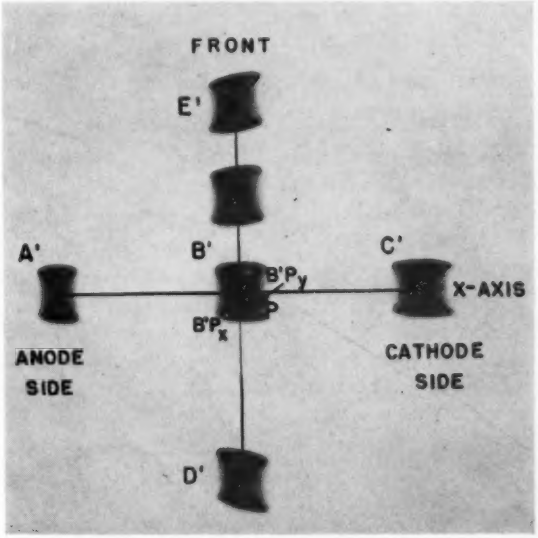
$$FF'=\frac{PB'\times F'B}{BB'} \tag{4}$$

and by substitution for $F'B$ from (2) above

$$FF'=\frac{PB'\times BC}{B'C'-BC}\cdot$$

By a similar method we also have

$$FF'=\frac{PB'\times BA}{B'A'-BA}\cdot$$



Since these values are for the projection of FF' in the x plane, the final form should be written

$$(FF')_x=\frac{(PB')_x\times BC}{B'C'-BC}$$

$$=\frac{(PB')_x\times BA}{B'A'-BA}\cdot \quad (5a \text{ and } b)$$

Considering the plane containing the y axis in the same manner, we have

$$(FF')_y=\frac{(PB')_y\times BD}{B'D'-BD}$$

$$=\frac{(PB')_y\times BE}{B'E'-BE} \quad (5c \text{ and } d)$$

The distances between the pinholes in the lead (BA etc.) are known, and distances between image centers ($B'A'$, etc.) are measured on the film. The measurements PB_x' and PB_y' are made from the projection of P onto the diagonals to the center of the target image, B'. FF_x' and FF_y' are computed from equations 5 above and the exact shift of the tube may then be made in the proper direction to make F' coincide with F. Again, directions are reversed on the film image (Fig. 3).

A check on the accuracy of the setup can readily be made from the film. It should be noted that no matter how F' is situated with respect to F in a particular case, since BA, BC, BD, and BE were constructed equal, and

$$\frac{F'B'}{F'B}=\frac{B'A'}{BA}=\frac{B'C'}{BC}=\frac{B'D'}{BD}=\frac{B'E'}{BE} \tag{6},$$

then

$$B'A'=B'C'=B'D'=B'E' \tag{7}\cdot$$

If this is not found to be true there is an error either in the placement of the pinholes in the lead, or the lead and film are not parallel.

Fig. 3. Test film made with multiple pinhole camera with construction for calculations.
$BA=BC=BD=BE=2.0$ cm. $B'A'=B'C'=B'D'=B'E'=5.4$ cm.
$(PB')_x=0.7$ cm. $(PB')_y=0.3$ cm.

$$(FF')_x=\frac{0.7\times 2.0}{5.4-2.0}=0.4 \text{ cm.} \qquad (FF')_y=\frac{0.3\times 2.0}{5.4-2.0}=0.2 \text{ cm.}$$

The target is 4 mm. too close to the cathode and 2 mm. too far back.

With the additional measurement of the lead to film distance, BP, the actual height of the target above the film (FP) may also be determined when the target is centered. In this case $BP=BB'$ and $FB=F'B$ and from formula 2 above

$$FB=\frac{BP\times BC}{B'C'-BC} \tag{8}$$

and the target-film distance is $FP=FB+BP$, or to calculate it directly

$$FP=\frac{BP\times B'C'}{B'C'-BC} \tag{9}$$

When using the multiple pinhole camera it is advisable to make 2 exposures for each test, the second with the camera rotated 180° with respect to the first. Irregularities such as improper alignment of B and P, or angulation of the cone or film, will appear in a shift of the position of the image B' with respect to P. If the fault cannot be corrected an average of the calculated off-center error may be used.

This method has the advantages of rigidity and accurate alignment with no extra equipment, excepting the lead plate. It is self-checking and in determining the off-center error there is no dependence on the knowledge of the target height, since neither the target-lead, nor the target-film distance enter into the calculations. In practice there is little actual calculation involved in locating the target precisely.

The centering problem became acute at the Presbyterian Hospital of the City of New York with regard to the positioning of a new roentgen tube in a new therapeutic type housing. Preliminary film tests indicated that the target was off center in two directions, causing a considerable cut-off on two sides of the field. For a 10 by 10 cm. field at 50 centimeter focal-skin distance, the cut-off extended approximately 1 cm. into the field at the surface. An attempt was made to locate and center the target with a single pinhole camera. However, the results were not reproducible due to wobble in the camera and difficulties in alignment. These difficulties led to the design and use of the multiple pinhole camera, which was found to be successful.

In attempting to center the tube industrial tolerances must be considered. The target was moved as close to the center of the field as was permitted by the design of the equipment, in the case mentioned above. It was possible to center it precisely along the long axis (target to cathode axis) of the tube. This was not possible along the short axis. The industrial tolerance of the tube is 1/16 in. or about 1.6 mm.; that of the tube-housing combination is a little greater. The target could be brought to within 2 mm. of the center in this direction. The field cut-off was considerably reduced. This adjustment had to be accepted as satisfactory since it was unreasonable to try to exceed the accuracy of the equipment. The cones are being redesigned with a less rigid diaphragming system in an effort to reduce the seriousness of the off-center error.

In the therapy tube the target is not a point, nor is its image in the pinhole photograph. However, an estimate can be made of the position of the center. A working film for the example mentioned above is shown in Figure 3, together with the measurements and calculations.

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The author wishes to express her gratitude to Mr. Jan Havinga for suggestions during the original development of the multiple pinhole camera, and to Dr. Edith Quimby for aid in preparing the material for publication. She also wishes to acknowledge her indebtedness to the American Cancer Society for the generous support of this study.

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A PHOTOFLUOROGRAPHIC FILM MOUNT*

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THE importance of comparison of roentgenograms of the chest, full size or miniature, made at various times cannot be overestimated. Anatomical variations and the end results of repeated inflammatory processes produce sufficient variability in the chest roentgenogram so that the difference between the normal and abnormal is frequently vague or may be overlooked. The ability to compare films made at reasonable intervals permits, therefore, the determination as to whether a hilar shadow, for example, is changing in size, or a small density in the periphery, difficult to separate from a vascular shadow or other insignificant process, is now changing sufficiently to demand urgent attention. In the diagnosis of carcinoma of the lung in its earliest recognizable stage, such comparisons may be crucial.

Because photofluorograms are made on rolls in which the films follow in chronological order, the labor involved in finding the film of any individual patient for comparison is of such an order as to militate against such comparative studies. Our own experience has taught us that the failure to make such comparisons because of the difficulty in finding earlier films has resulted occasionally in serious error. For these reasons it seemed desirable to create some type of arrangement which would make comparison of photofluorograms so readily available that the use of this measure would be greatly facilitated.

For such purposes, a cardboard film mount patterned after the usual full-mouth dental roentgen-ray film mounts, but capable of holding five 70 millimeter photofluorograms, was designed and has been in use at the University of Minnesota Hospital for a period of over three years. It was intended as a part of a study to determine whether comparative readings of photofluorograms would increase the yield of early bronchogenic carcinomas on routine photofluorograms. The study is still in progress and it is too early to evaluate the results. It was thought, however, that the mount might be of interest to others who study large numbers of photofluorograms, either as part of the routine study on admission to the hospital or periodic chest surveys on large groups, as in the health plans of large corporations, etc.

The mount is made of lightweight cardboard, contains slots for five films, and will fit into the ordinary 14 by 17 film envelope. The photofluorograms, made as part of the routine hospital admission study, can, therefore, be kept in the patient's radiologic department envelope along with the

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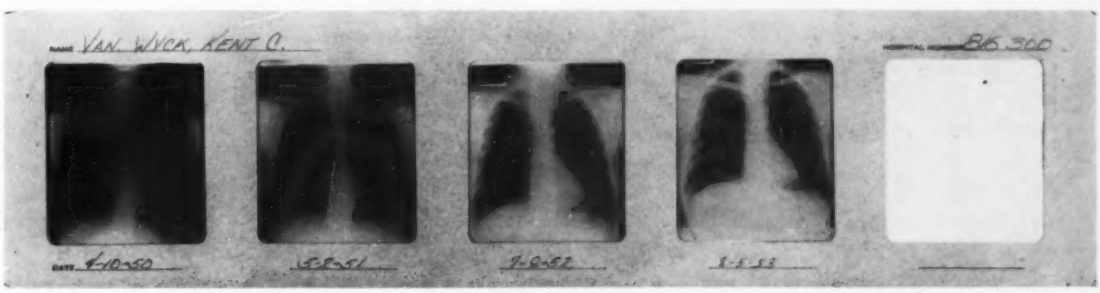

FIG. 1. Photograph of film mount illustrating method of mounting 70 mm. films, in this case, at yearly intervals. The fifth film had not yet been taken.

remainder of his films. The film mount with four films already mounted is shown in Figure 1. The date and number may be inscribed on the mount as illustrated.

The photofluorogram mount may be of value in the following ways: (1) borderline hilar changes may be more easily detected by comparison with previous films; (2) minor densities in the periphery of the lung may exhibit changes, especially increase in size, which are obvious by comparison but might not be clearly defined otherwise. The number of follow-up 14 by 17 films for the evaluation of such densities may be decreased if it is obvious that the shadows have not changed over varying periods of time. Such information is not usually available to the photofluorogram reader who must, therefore, recall a moderately large number of people even if they have been recalled on several previous photofluorographic surveys. (3) The mount constitutes a filing form and no other envelope or jacket is necessary for the routine storage of the fims.

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REPRODUCTION OF ROENTGENOGRAMS

A METHOD TO IMPROVE LANTERN SLIDES AND PHOTOGRAPHIC PRINTS

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THE demonstration of pathologic lesions by roentgenography is one of our most valuable diagnostic procedures. Because both the roentgenograms and pathologic lesions are of relatively small size, roentgenograms must be viewed at close range. Group teaching is limited, therefore, because of the restricted number of observers. Demonstration to large groups must be done with lantern slides. Photographs of roentgenograms to be converted into lantern slides or prints for publication, however, are often very unsatisfactory. The original film may demonstrate the lesion clearly but in reproduction the detail may be lost. The pathology seen in the original film may not be demonstrated by the photograph and lantern slide or if it is, it may be so altered as to give a false impression of the lesion.

The difficulty encountered in reproducing roentgenograms photographically is due to the marked variation in density. The greater the difference in density of various parts of the film, the more difficult it is to obtain a satisfactory photographic copy.

In a recent article on the treatment of ruptured intervertebral disks,[1,2] it was necessary to photograph the lower lumbar spine. In the lateral projection the lower vertebrae are overshadowed by both iliac crests. In the roentgenogram this area is always three or four shades lighter than the remainder of the film. I have spent a great deal of time working in a photographic dark room in an effort to obtain a print which would demonstrate the lesion as well as the original film.

With the aid and suggestion of Mr. Billy Burke, Hollywood surgical motion picture photographer, the following photographic technique was worked out which has proved to be a most valuable contribution to the reproduction of roentgenograms for lantern slides and photographic prints. The method usually employed is to copy the roentgenogram directly, then attempt to change the light and dark areas of the film to a more uniform density at the time of the printing. The new method of photographing roentgenograms herein described is based on the principle of interrupting the intensity of the transmitted light in local areas of the film at the time it is being copied. This is accomplished by placing patches of paper of different size, shape and density between the light source and the film to hold back light passing through the thin or underexposed areas of the film. A uniform density of the roentgenogram can thus be accomplished resulting in even light distribution. The important areas of the film can be brought out and made to appear more clear and often with better detail in the photographic copy than was seen in the original film.

APPARATUS AND TECHNIQUE

An "old fashioned" cone-shaped viewbox is used to transilluminate the roentgenogram for copying with a camera (Fig. 1, *6*). This type of viewbox is necessary because: (1) it utilizes an incandescent bulb for the light source, and (2) the box is sufficiently deep behind the opaque glass to permit easy manipulation of the "spotting patches." An opening 6 by 14 inches is cut out of the metal on the right side of the viewbox. A wooden block is made to fit the floor of the box (Fig. 1, *1*). The block can be made from one piece of wood or four separate boards 3/4 inch thick. If a solid $3\frac{1}{2}$ inch thick piece is used, three longitudinal slots are cut in it with a circular saw, 1 inch deep and $\frac{1}{8}$ or 3/16 inch wide. An easier method, however, is to nail together four separate boards each with a

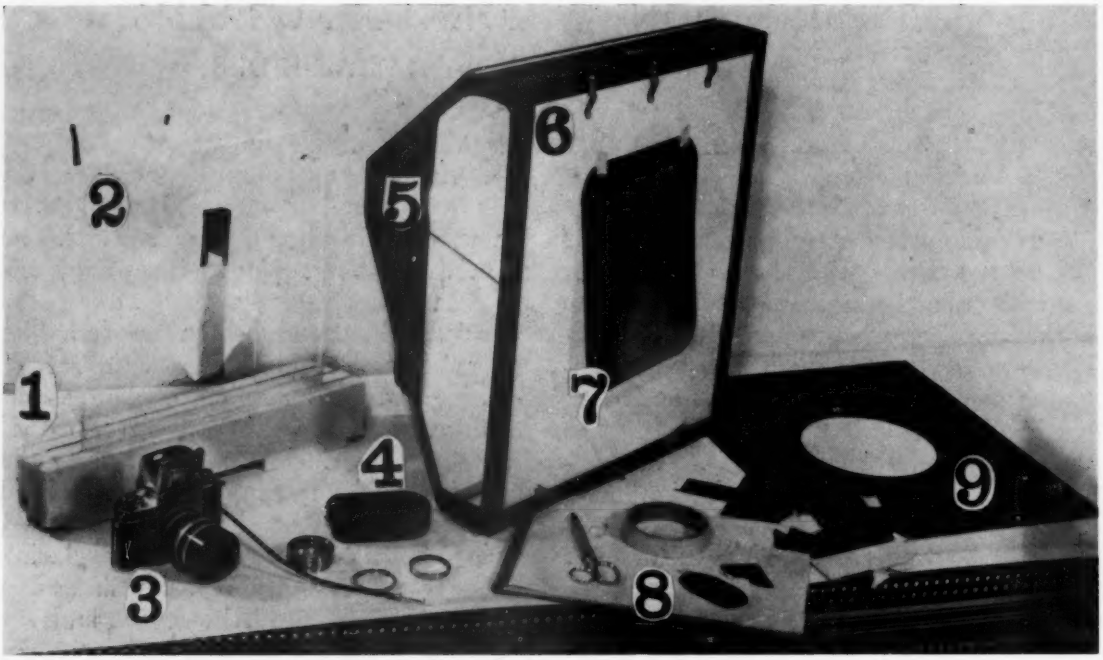

FIG. 1. Apparatus for photographing roentgenograms. (*1*) Wooden block with slots for glass plates. (*2*) Glass plates for spotting patches. (*3*) Reflex camera. (*4*) Weston light meter and portrait lenses. (*5*) Photoflood incandescent light bulb—#1 or #2. (*6*) "Old-fashioned" cone-shaped roentgen viewbox with opening 6 inches wide cut out of right side. (*7*) Roentgenogram to be photographed. (*8*) Equipment for making "spotting patches": tissue paper, old roentgenogram, scotch tape, scissors. (*9*) Thin black cardboard for masking roentgenogram.

strip of masonite $\frac{1}{8}$ by 2 by 15 inches bebetween them. The thin masonite strips are placed at the bottom of the larger boards leaving three $\frac{1}{8}$ inch slots above, 1 inch deep and 15 inches long. By cutting notches on the bottom side of the boards, irregularities in the floor of the viewbox can be fitted snugly (Fig. 1, *1*).

Two pieces of clear glass 10 by 12 by $\frac{1}{8}$ inches are used as the carriers upon which are pasted the spotting patches (Fig. 1, *2*). A 12 by 15 inch glass plate may be used for larger roentgenograms. The glass plates fit loosely in the slots in the block of wood and can be moved easily in and out of the viewbox. The glass may be made to slide more easily by covering the lower edge with a single strip of masking tape. The spotting patches (Fig. 1, *8*) are cut from an old roentgenogram or a rather heavy grade of tissue paper. By using an old roentgenogram different densities can be utilized ranging from the transparent to the black opaque areas of the film depending upon the amount of light one wishes to reduce. When tissue paper is used the desired density of the spotting patches is accomplished by superimposing several sheets of paper. The patches are cut to fit the light area of the roentgenogram, applied to the glass plate with scotch tape and the plate slid into the desired slot of the wooden block. With the spotting patches situated 2 inches or more behind the roentgenogram and between it and the light source, the light diffuses around the patch so the sharp outline of the patch does not appear on the roentgenogram but blends evenly into it. The sharpness of the outline of the patch can be varied by changing the plates to a slot closer or farther from the film, or by just tilting the plate forward or backward in the same slot until the desired shading effect has been obtained.

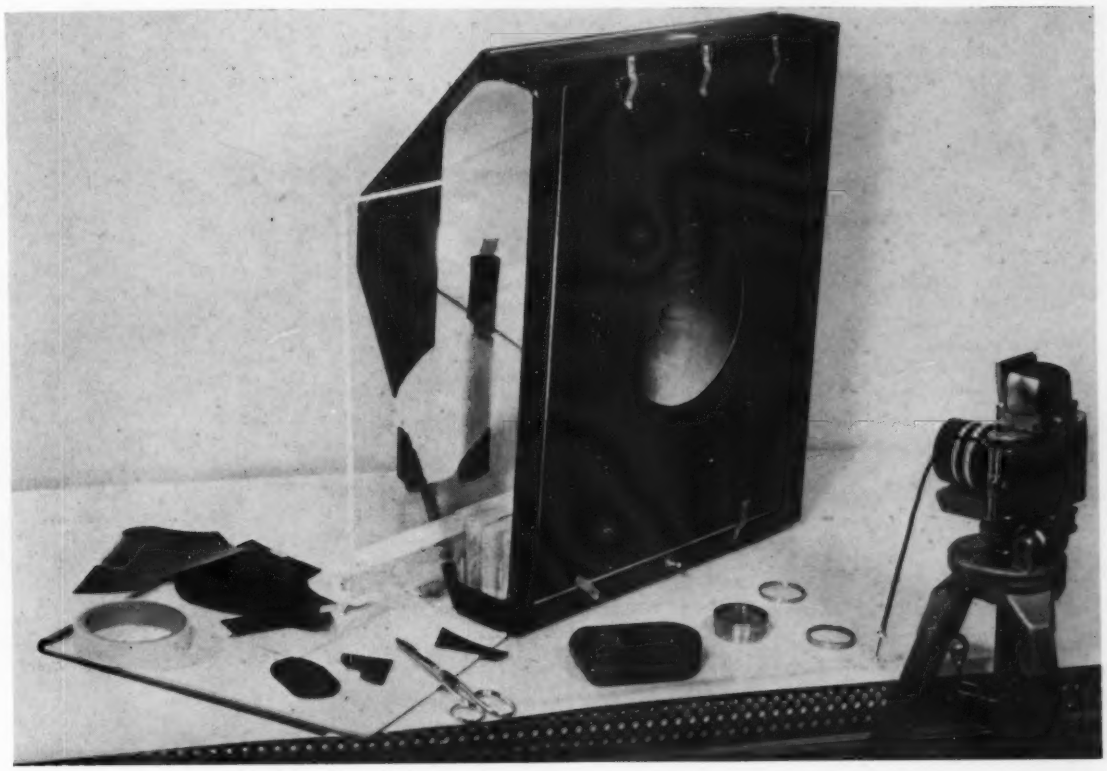

Fig. 2. Viewbox and "spotting" apparatus assembled in preparation for photographing roentgenograms.

The patches are moved about, increased or decreased in density and the glass plate moved forward or backward until all areas of the roentgenogram are transmitting a uniform intensity of light. This is checked photographically by using a Weston light meter (Fig. 1, *4*). With the light meter gate open for lower intensities of light the meter is placed in contact with the roentgenogram and moved about over the areas which are to be brought out in the photograph. When all areas of the roentgenogram have the same light meter reading or nearly so, then the film is ready to be photographed. The light source for transilluminating the film can be changed depending upon the density of the roentgenogram. Photoflood incandescent bulbs are preferred (Fig. 1, *5*), either a #1 or #2 white light. This bulb may become hot if it is permitted to burn for too long a time. But since the bulb is located at a considerable distance from the ground glass of the cone-shaped viewbox and with the large hole cut in the side of the box for ventilation, very little heat reaches the roentgenogram. The roentgenogram to be examined is attached to the front of the opaque glass of the viewbox with masking tape (Fig. 1, *7*). Extraneous light about the film, is blocked out by a large sheet of thin black cardboard (Fig. 1, *9*), with a central cut-out area of the desired size and shape. This is particularly essential in photographing small roentgenograms.

The camera for photographing the roentgenogram is placed upon a tripod directly in front of the viewbox (Fig. 2). A camera with a ground glass viewer is preferred because the object can be better framed and sharp focus insured. For 35 mm. slides, the Exacta, the Bolsey or other reflex cameras are useful (Fig. 1, *3*). If one wishes to photograph only a small part of the roentgenogram plus 2 or plus 3 portrait lenses (Fig. 1, *4*) may be used over the

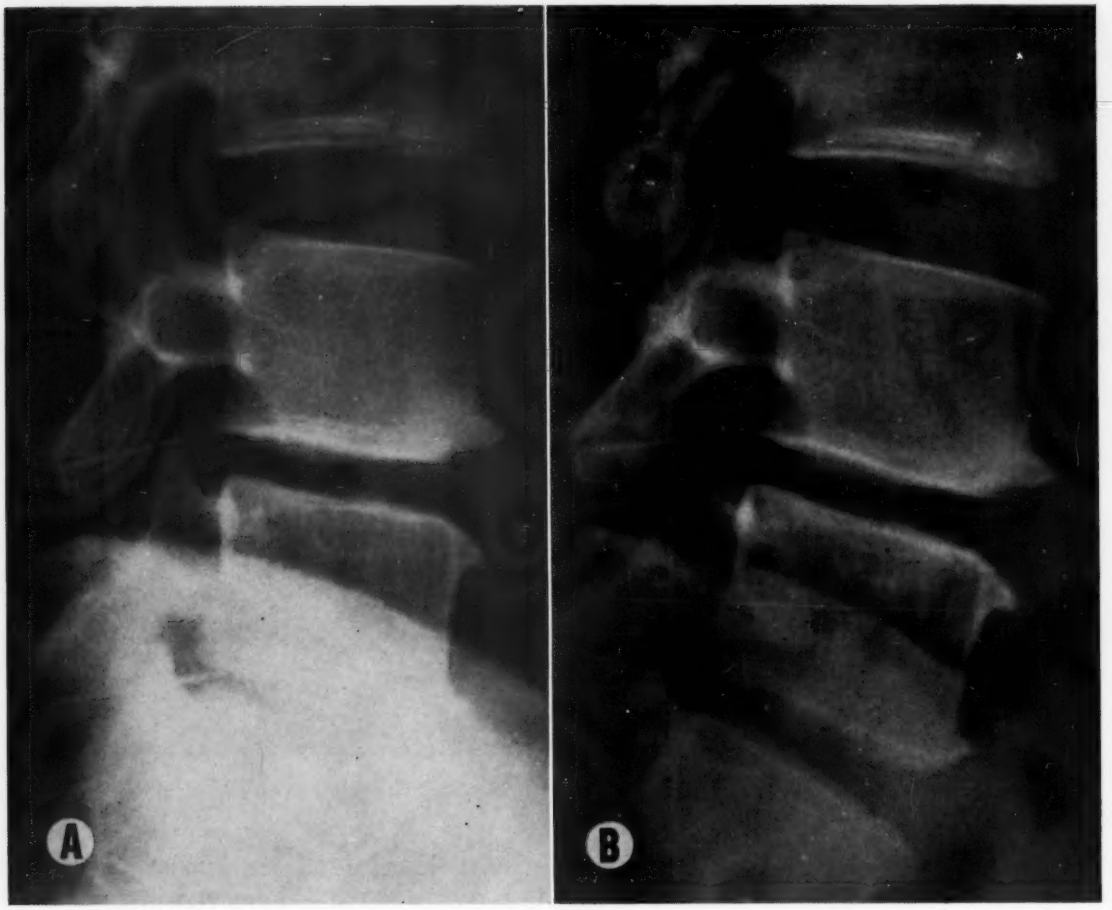

FIG. 3. (*A*) Photograph of a roentgenogram of lumbosacral spine made by the usual method of direct copy and contact print.

FIG. 3 (*B*) Same roentgenogram photographed after uniform lighting was achieved by use of "spotting patches."

standard 50 mm. lens for closeup photographs.

The choice of photographic film used to copy roentgenograms depends on the wishes of the photographer. The roentgenogram may be photographed with either positive or negative film. If direct positives are made for 35 mm. or 4 by 4 inch slides, kodachrome or ectachrome film for artificial light is used and a white photoflood bulb placed in the viewbox as the light source. If the roentgenogram is to be copied as a negative to be used for making photographic prints, a contrast, fine grain film is preferable. For this method of copying roentgenograms on 35 mm. black and white film, I have found Eastman's fine grain positive to give the most satisfactory results. This has a slow emulsion (Weston meter reading of 3) and has about the correct contrast for reproducing roentgenograms. The negative thus obtained is used for prints. It can also be reversed on the same kind of film (fine grain positive) as a positive which can then be mounted between glass and used as a lantern slide. Lantern slides thus prepared have better contrast and more detail than direct positives obtained with color film (kodachrome). Slides are easier to make using color film, however, because only one step in the copying procedure is necessary.

SUMMARY AND CONCLUSIONS

A method of photographing roentgenograms is presented. The technique is based upon obtaining uniform transmission of light through the roentgenogram at the time the photograph is taken. This is accomplished by placing opaque spotting patches on a glass plate behind the roentgenogram, i.e., between it and the light source, to reduce the amount of light passing through the thin areas of the film. The even lighting of the roentgenogram thus produced will result often in a photographic print or lantern slide which is an improvement over the original film (Fig. 3 *B*). It is hoped that an adoption of a method for copying roentgenograms similar to that herein described will serve to improve the caliber of published illustrations, and particularly lantern slides presented at medical meetings. When the audience is required to stretch their imagination to see the roentgen pathology in a lantern slide of poor quality (Fig. 3 *A*), a bad impression may result in what may have been an otherwise well presented paper.

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THE EFFECT OF POSTURE AND RESPIRATION ON THE SLIT KYMOGRAM OF NORMALS AND SUBJECTS WITH MITRAL STENOSIS*

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FOR several years, we have been using slit kymograms taken in the supine posture to provide data on the rate of diastolic filling of the left ventricle. In congestive myocardial failure and in constrictive pericarditis, as well as in high output due to anemia or beriberi, the left ventricle fills almost instantly in early diastole; often the filling curve is steeper than that of systolic emptying. In normal subjects, there may also be a plateau in mid-diastole, with a convex but less steep curve of early diastolic filling. In mitral stenosis, even when a systolic murmur suggests concomitant insufficiency, the filling slope is gradual and straight, giving a saw tooth pattern with a sharp systolic and a long diastolic slope.

A year ago, when our tricardiograph[1] for making kymograms in supine subjects was being rebuilt, we used the standard upright technique, and found greater variation in normal subjects with less dependable differentiation of the cases of mitral stenosis. In one case, febrile and with only a short diastolic murmur, one slit kymogram showed slow and small diastolic excursions of both right and left ventricular borders, while another, taken a few minutes later, showed much greater amplitude, and steeper slope to the filling curves of both borders. When this subject had ballistocardiograms inscribed and repeated breath holding just as he had done for the kymograms, it was seen that the amplitude of the systolic waves of the ballistocardiograms decreased markedly during the first twenty seconds after taking a deep breath and holding it. This led to a study of the effects of various respiratory maneuvers on the motion on the heart border in erect and supine subjects.

METHODS

In a group of 7 normals and 8 "mitral" subjects upright posteroanterior slit kymograms were taken during the following respiratory maneuvers:

I. Suspended breathing in normal mid-inspiration; the mouth held open so as to avoid any Valsalva effect.

II. Straining against the closed glottis after a full *expiration.*

III. Mueller maneuver—attempted inspiration against the closed glottis following a deep expiration.

IV. Flack maneuver—forced expiration against resistance† following a deep inspiration.

V. Reverse Flack maneuver—forced inspiration against resistance following a deep expiration.

In 6 of the rheumatic subjects mitral commissurotomy was later performed, and in these patients upright kymograms, using respiratory maneuvers I to V, were repeated after convalescence from operation.

In 3 normal and 2 "rheumatic" subjects, supine slit kymograms were made during respiratory maneuvers I to V. In 1 of the rheumatic group the supine kymograms were also made after commissurotomy, with the same respiratory maneuvers.

With both of our kymographs, film moves 1 cm./sec., and 1 mm. on the curves represents 0.1 sec.

† For the resistance breathing a U-tube of mercury filled to a height of 5 cm. was employed. The U-tube was mounted on the cassette carrier and a long rubber mouthpiece made easily accessible to the patient.

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Using a modified film enlarging device the individual frames of all kymograms were magnified 2.5 times and plotted on ruled paper. Lens to paper distance was fixed, thus assuring comparisons from film to film, taken by the same method. The records were then analyzed for diastolic filling time, shape and amplitude of diastolic filling and systolic ejection curves. The tube to film distance is exactly 90 cm. in the kymograph for erect position, and 92–97 cm. for the supine technique where the film carrier is 2–5 cm. above the sternum. The curves from the latter exaggerate the true motion slightly as compared with the former. Diastolic filling time was calculated as the average time of three frames from the mid-trough at the end of systolic rightward (inward) motion to the first distinct inflection at the end of leftward (outward) motion.

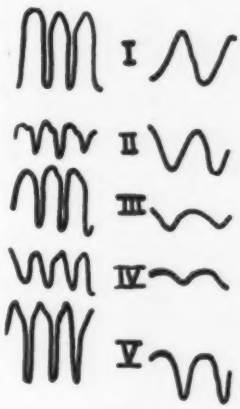

Fig. 2. A normal subject; left ventricular border motion during the five respiratory maneuvers. The curves in the left column are from the kymograms taken in the standing position; the right column from the kymograms taken in the supine position. Note the notching on the systolic (downward) curve in the standing position during respiratory maneuver II. All the frames were taken from the middle of the left ventricular border.

RESULTS

A. *Shape and Amplitude of Left Ventricular Pulsations.* In the 7 normal subjects studied by roentgen kymography in the upright position, the amplitude and shape of the left ventricular pulsations exhibited notable variation caused by changes in intrathoracic pressure and the position of the diaphragm. In the supine position, subjects showed less variation in shape and amplitude of pulsation in response to the same respiratory maneuvers. It was not uncommon to see small amplitude and slow filling in the left ventricular curves of normal subjects recorded in the upright position during a suspended respiration (Fig. 1). However, in the supine position this type of "mitral" curve is rarely evoked by the same maneuver. In a majority of the normal subjects, the amplitude of left ventricular pulsations becomes progressively smaller from the apex to the base, whereas in persons with mitral stenosis this gradation in pulsation is generally less evident. Although notching of the filling curve was not demonstrated in any of the kymograms of the 7 normal subjects taken during maneuver I, 5 of these subjects showed a systolic notch in one or more of the maneuvers II through V (Fig. 2).

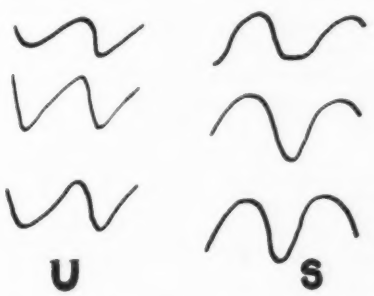

Fig. 1. Three simultaneous left ventricular frames from the kymograms of a normal subject. Films were taken minutes apart; *U*—in the standing position, *S*—in the supine position. Note the slow filling (upward) in the standing kymogram.

In 8 subjects with a clinical diagnosis of predominant mitral stenosis (6 confirmed at operation) upright roentgen kymograms similarly showed variation in left ventricular pulsation depending upon the type of respiratory maneuver (Fig. 3). The average size of left ventricular pulsations in the mitral patients was definitely less than in the normal group. This agrees with the catheter data[2] showing a smaller stroke

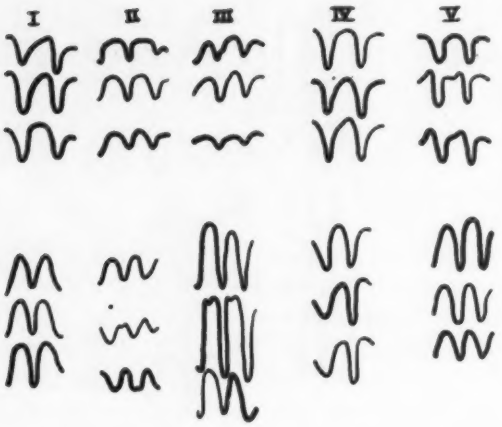

FIG. 3. Left ventricular border curves in a case of mitral stenosis. The kymograms were all taken in the standing position, and are three consecutive curves from each film. The upper group were taken preoperative during respiratory maneuvers I to V. The lower group are from the postoperative films during the same respiratory maneuvers. Note the slow filling during maneuver I preoperative, and compare with the same maneuver postoperative.

volume in subjects with mitral stenosis. Following commissurotomy in 5 out of 6 of these cases there was little or no increase in the amplitude of the left ventricular pulsations. Since the films were taken four to six weeks postoperatively, it is possible that with time the pulsations may increase in amplitude. In 1 of these cases pulsations of normal amplitude were recorded on the kymograms, taken in the erect and supine posture, five weeks after operation (Fig. 4). Ventricular rates were essentially the same before and after surgery in 5 out of the 6 cases.

B. *Diastolic Filling Time.* Table 1 gives the diastolic filling times in the 7 normal subjects. There is no constant effect of the various maneuvers from case to case, and great variation, under the same respiratory conditions, from subject to subject. It is recognized that ventricular rate will alter the data, and in general those with fast rates had the fastest filling times. In only 1 subject (W.D.) did the rates during the different maneuvers vary more than six beats per minute. It is obvious that the Flack and reversed Flack cause the most reproducible variations of conditions in the chest, and should produce maximal change in the average filling times.

In Table II are tabulated the diastolic filling times in the group of 8 subjects with a clinical diagnosis of predominant mitral stenosis. Six of the subjects had auricular fibrillation and 2 a regular sinus mechanism. Of the 6 subjects who underwent mitral commissurotomy 4 had auricular fibrillation and 2 sinus rhythm. All maintained their previous cardiac rhythm after operation. One subject (E.R.) had a significantly more rapid ventricular rate after operation.

The data in Table II indicate that with all respiratory maneuvers a shortening of diastolic filling time can be demonstrated

TABLE I

STANDING DIASTOLIC FILLING TIMES (IN SECONDS) IN NORMAL SUBJECTS DURING FIVE RESPIRATORY MANEUVERS

Subject	Maneuver I	Maneuver II	Maneuver III	Maneuver IV	Maneuver V
A.W.	.31	.38	.31	.31	.25
H.R.	.38	.31	.31	—	—
L.B.	.44	.34	.28	—	—
B.P.	.47	.44	.38	.50	.38
W.D.	.31	.25	.31	.49	.25
P.W.	.28	.25	.25	.34	.25
W.W.	.25	.19	.19	.19	.22
Average	.35	.31	.29	.37	.27
Range	(.47–.25)	(.44–.19)	(.38–.19)	(.50–.19)	(.38–.22)

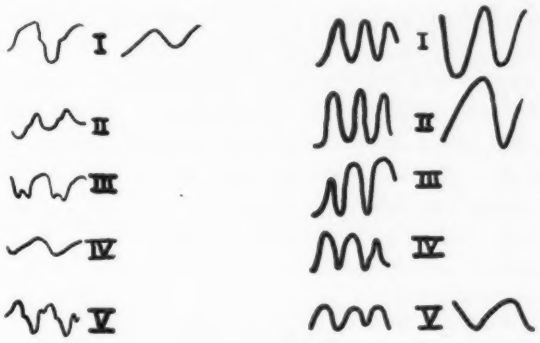

FIG. 4. A comparison of preoperative (left group of curves) and postoperative (right group of curves) kymograms (during 5 respiratory maneuvers) in a subject with mitral stenosis. The five left ventricular frames in the first column were taken in the standing position. Only one preoperative kymographic film taken in the lying position was available. The third (standing) and fourth (supine) columns show both a loss of notching and a striking increase in amplitude of the waves after mitral commissurotomy. Note particularly the slow filling and low amplitude in the preoperative supine curve during maneuver I and compare with the more rapid filling and increased amplitude in the postoperative supine film during the same maneuver.

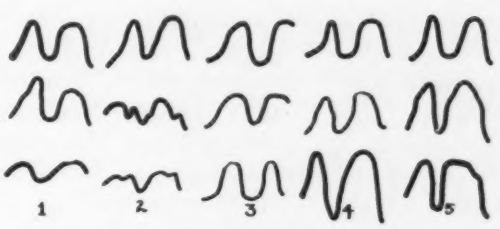

FIG. 5. Groups of three frames from five different standing kymograms taken within ten minutes of each other on the same normal subject. The subject was positioned by one technician and the films exposed during the routine command, "Take a breath, hold it!"

after operation (Fig. 3). The greatest percentage change is to be found with the simplest maneuver, namely, held mid-respiration. Our observations during these maneuvers in supine normal subjects and patients with mitral stenosis are not numerous enough to justify tabulation, but they suggest there is less variation in filling times when kymography is done in the supine position. Venous return is presumably greater and more constant in the recumbent than in the erect posture.

DISCUSSION

The first suggestion that the shape and slope of left ventricular border motion recorded by roentgen kymography might be useful in the evaluation of mitral valvular disease was made in 1936.[3] Although this is a safe and simple method, one is struck by the lack of interest in its general use as a diagnostic criterion for mitral incompetence or stenosis.

TABLE II

STANDING DIASTOLIC FILLING TIME (IN SECONDS) PRE- AND POST-COMMISSUROTOMY IN EIGHT SUBJECTS WITH MITRAL STENOSIS DURING FIVE RESPIRATORY MANEUVERS

Subject	Maneuver I			Maneuver II			Maneuver III			Maneuver IV			Maneuver V		
	Pre	Post		Pre	Post		Pre	Post		Pre	Post		Pre	Post	
A.S.	.44	.25	(43)*	.25	.25	(0)	.31	.25	(19)	.47	.31	(34)	.34	.25	(27)
J.C.	.44	.30	(32)	.25	.23	(8)	.31	.18	(42)	.38	.26	(32)	.31	.26	(16)
J.A.	.50	.38	(24)	*.25*	*.28*	(12)	.19	.19	(0)	.31	.31	(0)	.31	.22	(29)
E.R.	.44	.22	(50)	.31	.19	(39)	.31	.25	(19)	.38	.25	(34)	.31	.28	(10)
M.A.	.28	.19	(32)	.25	.22	(12)	.25	.19	(24)	.25	.22	(12)	.25	.22	(12)
F.D.	.41	.38	(7)	.38	.31	(18)	.34	.31	(9)	.44	.31	(30)	.31	.25	(19)
B.R.	.38	—		.38	—		.28	—		.41	—		.38	—	
E.D.	.44	—		.38	—		.38	—		.34	—		.31	—	
Average	.42	.29	(31)	.26	.25	(4)	.28	.23	(18)	.36	.28	(22)	.31	.25	(19)

* The figures in parentheses represent the percentage decrease in diastolic filling time postoperatively as compared with its corresponding preoperative value. The italicized figures for subject J.A. during maneuver II show an increased filling time following surgery. The postoperative kymograms were taken shortly after recovery from a full blown post-commissurotomy syndrome which included left sided pleuritis.

The present study has pointed out the variability inherent in kymography, as it is usually done in erect subjects simply told to "Take a deep breath. Hold it." (Fig. 5.) In the erect position the apical portion of the heart tends to fill rapidly in early diastole, the convexity towards the base tending to remain motionless or moving slowly leftward as the ventricle elongates. Later, the apex ceases to move as the more basal portion of the ventricle fills. Thus more rapid leftward motion would occur in the upper portions of the left ventricle toward the end of rapid ventricular filling. This may account for the gradual slope of some segments in a normal subject. The erect posture minimizes the change in border motion seen in mitral stenosis partly because of this effect, partly because venous return is reduced and is more affected by respiration. When patients with mitral stenosis are recumbent, elongation of the ventricle is less marked and motion of both apex and basal portions of the left ventricle are more uniform. Since the amplitude and shape of left ventricular pulsations are dependent upon venous return, the variations observed in the kymograms of erect normal subjects are due to the fact that decreased venous return, due to expiration, is most marked when one is erect, and may abolish the difference between normal persons and those with mitral stenosis.

One striking observation has been the uniform value of preoperative and postoperative slit kymograms for providing simple objective evidence of altered hemodynamics following mitral commissurotomy. Although it might be expected that the Mueller or reversed Flack maneuvers (which increase venous return) would give the greatest amount of information, it is apparent that the simplest maneuver, *i.e.*, held mid-respiration, is quite satisfactory. It will be noted (Table II) that the average postoperative filling times during all maneuvers are shortened, even though border motion did not increase notably. Although the exact respiratory phase may not be duplicated, even in the erect subjects, there was demonstrated a reduction in the left ventricular filling time after successful commissurotomy.

CONCLUSIONS

1. The shape and amplitude of left ventricular pulsations as recorded by slit kymography are markedly influenced by posture and respiration so that exactly reproducible films in the same subject are often unattainable.

2. These undesirable variations due to the effects of respiration are minimized in the recumbent position.

3. For the purpose of demonstrating hemodynamic alterations due to surgery for mitral valve disease, comparison of preoperative and postoperative kymograms are of value.

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It is a pleasure to acknowledge the technical help given by Mr. L. DeVito and Mr. L. Ruskin in recording the kymograms.

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Fifty-seventh Annual Meeting: Statler Hotel, Los Angeles, Calif., September 25–28, 1956.

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Thirty-eighth Annual Meeting: Shamrock Hotel, Houston, Texas, April 9–11, 1956.

EDITORIAL

A HALF CENTURY'S DEVELOPMENT OF X-RAY GENERATORS

THE basic method of producing x-rays is today essentially the same as that used by Röntgen in his epoch-making discovery—electrons freed from a metal cathode are accelerated to high velocity and then caused to strike a dense target.

Prior to the publication of the first number of the JOURNAL, much progress had been made in improving the early (gas-filled) x-ray tube, and in the development of a suitable high voltage source for its operation.

Since then, many changes have taken place both in the x-ray tube itself and in the means of accelerating its electrons. These changes have been due to the efforts of many scientists and engineers and to effective ccoperation between them and the users of the epuipment.

Some of these changes were made possible by developments in other fields, originally unrelated to x-ray production. This was true, for example, in the case of the substitution of wrought tungsten for the platinum previously used as the target material in the gas tube. The new material, wrought tungsten, became available through incandescent lamp development.

The tungsten target increased both the power and the ruggedness of the gas tube. Even so, however, the gas-filled tube had serious limitations. Most of these were due to its gas content; but without this, the tube couldn't operate.

It was the generally accepted scientific opinion of the time, that no electric current could flow through gas-free space between gas-free electrodes. The work of Dr. Irving Langmuir, however, showed that thermionic emission and current flow from filaments of tungsten were actually favored by freeing them from gas. This fact made possible, in 1913, the first high-vacuum, hot-cathode x-ray tube.

To make an operable tube of this type was at first difficult, as there was so much gas to be removed from its massive electrodes, and as high-vacuum pumps of that period were so slow in action. Even with thin all-tungsten electrodes, adequate gas removal necessitated several days of high voltage operation on the pump. It even seemed questionable at that time whether copper-backed targets could ever be sufficiently outgassed for a high-vacuum tube. Exhaust difficulties were, however, greatly reduced by Dr. Langmuir's invention of the condensation type of vacuum pump which was developed into something vastly faster than its predecessors.

The elimination of the gas from the x-ray tube not only greatly increased its flexibility but facilitated its precise control. It also made it possible to build tubes for several times the voltage which could be used with the gas tube.

A later development in the high vacuum tube, consisting in the use of a multiplicity of electrodes so as uniformly to grade the potential, made it possible, seemingly, to build tubes for any voltage, no matter how high.

The high vacuum tube was also capable of operation directly from a transformer, without auxiliary rectifying device. This made it possible to enclose it in the same metal container with a transformer, thus simplifying the equipment and facilitating protection from high voltage and from stray radiation.

For applications in which light weight and simplicty were not too important, it was still desirable to have rectified current. The mechanical rectifier, which had been used with the gas tube, was noisy and

bulky; but by 1915 a high vacuum, hot cathode rectifying tube, the kenotron, had been developed and described by Dr. Saul Dushman. Four kenotrons, placed in the same tank with the high voltage transformer, gave full-wave silent rectification.

As the milliamperage in a high vacuum x-ray tube changes rapidly with the temperature of the cathode filament, which in turn is affected by line voltage fluctuations, the development by W. K. Kearsley in 1920, of a milliamperage stabilizer was important. This automatically guarded against the effect of line voltage change and against that of possible change in electron emissivity.

For roentgenography, it was desirable that the x-ray output per projected unit of focal area should be as great as possible. This was partly facilitated by the use of the linear focal spot. It was carried still further by the successful development of the rotating target.

For deep x-ray therapy and for the roentgenography of thick, dense metal sections, a suitable source of very high voltage became desirable. This led to the development of Van de Graaff electrostatic generators for several million volts, and to the invention by Drs. W. F. Westendorp and E. E. Charlton of the low frequency resonance transformer.

A substantial reduction in the size and weight of x-ray high voltage transformers has been made by the use of gaseous dielectrics, such as sulphur hexafluoride, instead of oil.

In the preceding, reference has been made only to those systems in which the energy imparted to the electrons is that corresponding to the total voltage impressed on the tube.

In 1940, with the revolutionary development of the betatron by Dr. D. W. Kerst, it became possible to greatly increase the energy which could be imparted to an electron, by causing it to make many turns around a magnetic field while the latter is increasing in strength.

The synchrotron concept, according to which an electron is brought to high energy by successive applications of radio frequency energy, was described independently by Drs. E. M. McMillan, V. I. Veksler and M. L. Oliphant. With initial betatron acceleration as devised by Drs. W. F. Westendorp and H. C. Pollock, "synchrotron" apparatus has been developed for energies corresponding to voltages of several hundred million.

Another interesting device, the linear accelerator, differs from the betatron and synchrotron in that its electron path is linear instead of circular, the energy being imparted by a traveling wave. This is also capable of being built for very high energies.

As a result of the progress made during the half century, in the development of x-ray generating equipment, the available x-ray spectrum has been extended from that corresponding to a hundred thousand volts to that of several hundred million.

The development of means for producing high energy x-rays has, of necessity, resulted in the production of equally high energy cathode rays; and by the use of a thin window, these are brought out into the air for bactericidal, chemical and other purposes.

Throughout the half century, the JOURNAL has recorded faithfully and in detail these and other x-ray apparatus developments, apart, of course, from reporting on their medical use. This has been a stimulus and a help to apparatus development, in addition to what it has done for the medical application. The JOURNAL has thus attained a standing and an influence which will insure its continued useful existence. On that record and for its future prospects, I offer heartiest congratulations to the Editorial Staff.

W. D. Coolidge

General Electric Company
Research Laboratory
Schenectady, New York

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

MEETINGS OF RADIOLOGICAL SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. Barton R. Young, Germantown Hospital, Philadelphia 44, Pa. Annual meeting: Statler Hotel, Los Angeles, Calif., Sept. 25–28, 1956.

AMERICAN RADIUM SOCIETY
Secretary, Dr. R. E. Fricke, Mayo Clinic, Rochester, Minn. Annual meeting: Shamrock Hotel, Houston, Texas, April 9–11, 1956.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 713 E. Genesee St., Syracuse 2, N. Y. Annual meeting: Palmer House, Chicago, Ill., Dec. 11–16, 1955.

AMERICAN COLLEGE OF RADIOLOGY
Executive Secretary, William C. Stronach, 20 N. Wacker Drive, Chicago 6, Illinois. Annual meeting: 1956, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. T. Leucutia, Harper Hospital, Detroit 1, Mich. Annual Meeting: June 11–15, 1956, Chicago, Illinois.

EIGHTH INTERNATIONAL CONGRESS OF RADIOLOGY
Secretary General, Dr. José Noriega, Calle del Oro 15, Mexico 7, D. F. Meets Mexico City, July 22–28, 1956.

ALABAMA RADIOLOGICAL SOCIETY
Secretary, Dr. J. A. Meadows, Jr., Medical Arts Bldg., Birmingham 5, Ala. Meets time and place Alabama State Medical Association.

ARIZONA RADIOLOGICAL SOCIETY
Secretary, Dr. J. J. Riordan, 550 W. Thomas Rd., Phoenix, Ariz. Two regular meetings a year. The annual meeting at time and place of State Medical Association and interim meeting six months later.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. A. Norton, 843 Donaghey Bldg., Little Rock, Ark. Meets every three months and also at time and place of State Medical Association.

ASSOCIATION OF UNIVERSITY RADIOLOGISTS
Secretary, Dr. Robert J. Bloor, 260 Crittenden Blvd., Rochester 20, New York. Annual meeting, May, 1956 at the University of Rochester, N.Y.

ATLANTA RADIOLOGICAL SOCIETY
Secretary, Dr. Charles M. Silverstein, 3254 Peachtree St., N.E., Atlanta, Ga. Meets monthly, except during three summer months, on second Friday evening.

BLOCKLY RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Finkelman. Annual dinner: May, 1956.

BROOKLYN RADIOLOGICAL SOCIETY
Secretary, Dr. Theodore Kamholtz, 152 Clinton Street, Brooklyn, N. Y. Meets first Thursday of each month October through May.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. J. J. Daversa, 345 75th St., Brooklyn, N. Y. Meets monthly fourth Tuesday, October through April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Clayton G. Weig, 135 Linwood Ave., Buffalo, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse, N. Y. Meets January, May, November.

CENTRAL OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. Arthur R. Cohen, 41 S. Grant Ave., Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, November, January, March and May at Fort Hayes Hotel, Columbus, Ohio.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. E. Burns Lewis, 670 N. Michigan Ave., Chicago 11, Ill. Meets second Thursday of each month, October to April inclusive at the Sheraton Hotel.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. A. S. Tucker, 2020 East 93 St., Cleveland 6, Ohio. Meetings at 7:00 P.M. on fourth Monday of each month from October to April at Tudor Arms Hotel.

COLORADO RADIOLOGICAL SOCIETY
Secretary, Dr. Dorr H. Burns, 1776 Vine St., Denver, Colo. Meets third Friday of each month at University of Colorado Medical Center or at Denver Athletic Club.

CONNECTICUT VALLEY RADIOLOGIC SOCIETY
Secretary, Dr. T. J. Crowe, 53 Center St., Northampton, Mass. Meets second Friday October and April.

DALLAS-FORT WORTH RADIOLOGICAL CLUB
Secretary, Dr. A. H. Keene, 3707 Gaston Ave., Dallas, Texas. Meets monthly, third Monday, at Greater Fort Worth International Airport at 6:30 P.M.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. F. Lang, Harper Hospital, Detroit, Mich. Meets monthly first Thursday, Oct. through May, at David Whitney House, 4421 Woodward Ave., at 6:30 P.M.

EAST BAY ROENTGEN SOCIETY
Secretary, Dr. Dan Tucker, 434 30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland.

FLORIDA RADIOLOGICAL SOCIETY
Secretary, Dr. D. H. Gahagen, 320 Sweet Bldg., Fort Lauderdale, Fla. Meets twice annually, in the spring with the annual State Society meeting, and in the fall.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. B. H. Malone, 1406 Reynolds St., Brunswick, Ga.

GREATER MIAMI RADIOLOGICAL SOCIETY
Secretary, Dr. A. S. Capi, 300 N. 20th Ave., Hollywood, Fla. Meets monthly third Wednesday at 8 P.M. at various South Florida Hospitals.

HOUSTON RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Owsley, 6409 Fannin, Houston 25, Texas. Meets fourth Monday each month at Texas Children's Hospital.

IDAHO STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Alfred M. Stone, St. Lukes Hospital, Boise, Idaho. Meets annually at same time as Idaho State Medical Association.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Stephen L. Casper, 1101 Maine St., Quincy, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. C. A. Stayton, 313 Hume-Mansur Bldg., Indianapolis 4. Meets first Sunday in May and during fall meeting of Indiana State Medical Association.

IOWA RADIOLOGICAL SOCIETY
Secretary, Dr. James T. McMillan, 1104 Bankers Trust Bldg., Des Moines, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. The scientific section is held in the autumn.

* Secretaries of societies are requested to send timely information promptly to the Editor.

Kansas Radiological Society
Secretary, Dr. A. M. Cherner, Hays, Kansas. Meets in spring with State Medical Society, and in winter on call.

Kentucky Radiological Society
Secretary, Dr. David Shapiro, 217 East Chestnut St., Louisville 2, Ky. Meets monthly on second Friday at Seelbach Hotel, Louisville.

Kings County Radiological Society
Secretary, Dr. Solomon Maranov, 1450 51st St., Brooklyn 19, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

Los Angeles Radiological Society
Secretary, Dr. Richard A. Kredel, 65 North Madison Ave., Pasadena, Calif. Meets second Wednesday each month at Los Angeles County Medical Association Building, Los Angeles.

Maine Radiological Society
Secretary, Dr. W. A. Russell, Augusta General Hospital, Augusta, Maine. Meets in June, October, December and April.

Maryland Radiological Society
Secretary, Dr. Paul W. Roman, 1810 Eutaw Place, Baltimore 17, Maryland.

Memphis Roentgen Society
Secretary, Dr. B. E. Greenberg, 294 Annella St., Memphis 11, Tenn. Meets first Monday of each month at John Gaston Hospital.

Miami Valley Radiological Society
Secretary, Dr. G. A. Nicoll, 134 Apple St., Dayton, Ohio. Meets second Friday of fall and winter months.

Mid-Hudson Radiological Society
Secretary, Dr. J. W. Walton, Horton Memorial Hospital, Middletown, N. Y. Meets 8:30 P.M., fourth Tuesday each month, September to May.

Milwaukee Roentgen Ray Society
Secretary, Dr. R. W. Byrne, 3321 N. Maryland Ave., Milwaukee 1, Wis. Meets monthly on fourth Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. O. J. Baggenstoss, 1953 Medical Arts Bldg., Minneapolis, Minn. Meets three times annually, once at time of State Med. Assn., and in spring and fall.

Mississippi Radiological Society
Secretary, Dr. James M. Packer, 621 High St., Jackson, Miss. Meets third Thursday of each month at Hotel Edwards, Jackson, at 6:00 P.M.

Montana Radiological Society
Secretary, Dr. John Stewart, 1105 Frederick Lane, Billings, Montana. Meets at least once a year.

Nassau Radiological Society
Secretary, Dr. Frances Behrendt, 19 Clinton Rd., Garden City, N. Y. Meets second Tuesday of the month in February, April, June, October and December.

Nebraska Radiological Society
Secretary, Dr. J. F. Kelly, Jr., 816 Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Raymond A. Dillon, 24 Wedgemere Ave., Winchester, Mass. Meets third Friday of each month, October through May, at Hotel Commander, Cambridge, Mass.

New Hampshire Roentgen Ray Society
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

New York Roentgen Society
Secretary, Dr. M. H. Poppel, 303 E. 20th St., New York 3, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Radiological Society
Secretary, Dr. W. C. Sternbergh, Charlotte Memorial Hospital, Charlotte, N. C. Meets in May and October.

North Dakota Radiological Society
Secretary, Dr. Marianne Wallis, St. Joseph's Hospital, Minot, N. Dak. Meetings by announcement.

North Florida Radiological Society
Secretary, Dr. Marvin Harlan Johnston, Five Points Medical Center, Jacksonville, Fla. Meets quarterly in March, June, September and December.

Northeastern New York Radiological Society
Secretary, Dr. Robert R. Wadlund, Albany Hospital, Albany, N. Y. Meets in Albany area on second Wednesdays of October, November, March and April.

Northern California Radiological Society
Secretary, Dr. H. B. Stewart, 2920 Capitol Ave., Sacramento, Calif. Meets at dinner last Monday of each month, September to June.

Ohio State Radiological Society
Secretary, Dr. John R. Hannan, 10515 Carnegie Ave., Cleveland 6, Ohio. Annual meeting, Deshler-Hilton Hotel, Columbus, Ohio, May 12–13, 1956.

Oklahoma State Radiological Society
Secretary, Dr. John R. Danstrom, Medical Arts Bldg., Oklahoma City, Okla. Three regular meetings annually.

Oregon Radiological Society
Secretary, Dr. N. L. Bline, 210 Jackson Tower, Portland 5, Ore. Meets monthly from October to June on the second Wednesday of each month at 8:00 P.M. at the University Club.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

Pacific Northwest Radiological Society
Secretary, Dr. J. R. Raines, 214 Medical-Dental Bldg., Portland 5, Oregon. Meets annually in May.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. Walter P. Bitner, 234 State Street, Harrisburg, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. H. M. Stauffer, Temple University Hospital, Philadelphia 40, Pa. Meets first Thursday of each month, at 5 P.M., from October to May in Thompson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary, Dr. N. Tannehill, 500 Penn Ave., Pittsburgh 22, Pa. Meets second Wednesday of month, October through June at Hotel Roosevelt.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Paul W. Roman, 1810 Eutaw Place, Baltimore 17, Md. Meets third Tuesday each month, September to May, inclusive.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Radiological Society of Greater Cincinnati
Secretary, Dr. R. J. Neubauer, 831 Carew Tower, Cincinnati, Ohio. Meets monthly from September to May on first Monday of each month at 7:30 P.M. at the Cincinnati General Hospital.

Radiological Society of Hawaii
Secretary, Dr. George W. Henry, 1133 Punchbowl, Honolulu, T. H. Meets third Monday evening of each month at designated hospitals.

Radiological Society of Greater Kansas City
Secretary, Dr. E. H. Stratemeier, Jr., 1010 Rialto Building, Kansas City 6, Mo. Meets last Friday of each month.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Radiological Society of Louisiana
Secretary, Dr. W. S. Neal, 602 Pere Marquette Bldg., New Orleans, La. Meets annually during Louisiana State Medical Society Meeting.

Radiological Society of New Jersey
Secretary, Dr. G. G. Green, 601 Grand Ave., Asbury Park, N. J. Meets at Atlantic City at time of State Medical Society and in November in Newark, N. J.

Radiological Society of Southern California
Secretary, Dr. J. B. Irwin, 1831 Fourth Ave., San Diego, Calif.

Richmond County Radiological Society
Secretary Dr. W. F. Hamilton, Jr., University Hospital, Augusta, Ga. Meets first Thursday of each month at various hospitals.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Henry H. Forsyth, Jr., 40 Meigs St., Rochester, N. Y. Meets at 8:15 P.M. on the last Monday of each month, September through May, at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. John H. Freed, 4200 East Ninth St., Denver 20, Colo.

St. Louis Society of Radiologists
Secretary, Dr. Edwin C. Ernst, Jr., 3720 Washington Ave., St. Louis 8, Mo. Meets fourth Wednesday each month, except June, July, Aug. and Sept.

San Antonio-Military Radiological Society
Secretary, Dr. Hugo F. Elmendorf, Jr., 730 Medical Arts Bldg., San Antonio 5, Texas Meets Brooke Army Medical Center Officers Mess first Monday of each month.

San Diego Radiological Society
Secretary, Dr. J. C. Asher, 2001 Fourth Ave., San Diego 1, Calif. Meets first Wednesday of each month at the University Club.

San Francisco Radiological Society
Secretary, Dr. Howard L. Steinbach, University of California Medical Center, San Francisco 22, Calif. Meets quarterly at Grison's Steak House.

Section on Radiology, California Medical Association
Secretary, Dr. H. R. Morris, 1027 "D" St., San Bernardino, Calif.

Section on Radiology, Connecticut State Medical Society
Secretary, Dr. J. Burbank, Meriden Hospital, Meriden, Conn. Meetings are held bi-monthly.

Section on Radiology, Medical Society of the District of Columbia
Secretary, Dr. F. V. Schumacher, 1835 Eye St., N.W., Washington 6, D. C. Meets Medical Society Library, third Wednesday of January, March, May and October at 8:00 P.M.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. George E. Irwin, Jr., 703 N. East St., Bloomington, Ill.

Shreveport Radiological Club
Secretary, W. R. Harwell, 608 Travis St., Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M. September to May inclusive.

South Bay Radiological Society
Secretary, Dr. T. N. Foster, 630 E. Santa Clara St., San Jose, Calif. Meets second Wednesday of each month.

South Carolina Radiological Society
Secretary, Dr. S. W. Lippincott, 103 Rutledge Ave., Charleston, S. C. One meeting with South Carolina Medical Association in May, others arranged by President.

Southwestern Radiological Society
Secretary, Dr. Gordon Black, Suite 2-A, El Paso Medical Center, 1501 Arizona, El Paso, Texas. Meets second Tuesday of each month.

Tennessee Radiological Society
Secretary, Dr. G. K. Henshall, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas. Next Meeting, Fort Worth, Texas, Jan. 20–21, 1956.

Tri-State Radiological Society
Secretary, Dr. E. L. Hendershot, 118 S.E. First St., Evansville, Ind. Meets last Wednesday of Oct., Jan., March and May, 8:00 P.M. at Elks' Club in Evansville.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7:00 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May, Service Memorial Institute.

Upper Peninsula Radiological Society
Secretary, Dr. A. Gonty, Menominee, Mich. Meets quarterly.

Utah State Radiological Society
Secretary, Dr. Angus K. Wilson, 343 S. Main St., Salt Lake City 1, Utah. Meets fourth Wednesday in January, March, May, September and November at Holy Cross Hospital.

Virginia Radiological Society
Secretary, Dr. P. B. Parsons, Norfolk General Hospital, Norfolk, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Eva L. Gilbertson, 1317 Marion St., Seattle 4, Wash. Meets fourth Monday of each month from September through May at 610 Pine St., Seattle.

West Virginia Radiological Society
Secretary, Dr. W. Paul Elkin, 515 Medical Arts Bldg., Charleston, W. Va. Meets concurrently with annual meeting of West Virginia State Medical Society; other meetings arranged by program committee.

Westchester Radiological Society
Secretary, Dr. M. G. Priestman, New Rochelle Hospital, New Rochelle, N. Y. Meets on third Tuesday of January and October and on two other dates.

Wisconsin Radiological Society
Secretary, Dr. W. W. Moir, 309 Geele Ave., Sheboygan, Wis. Special meetings held during year; annual meeting each spring at Madison, Wis.

X-Ray Study Club of San Francisco
Secretary, Dr. J. T. English, 2000 Van Ness Ave., San Francisco 9, Calif. Meets monthly, third Thursday at 7:45 P.M., Lane Hall, Stanford University Hospital.

Cuba, Mexico, Puerto Rico and Central America

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

Sociedad Mexicana de Radiología, A. C.
Calle del Oro No. 15, Mexico 7, D. F.
Secretary General, Dr. Guillermo Santín. Meets first Monday of each month.

Asociación Puertorriqueña de Radiología
Secretary, Dr. Rafael A. Blanes, P. O. Box 9067, Santurce, Puerto Rico.

Sociedad Radiológica Panameña
Secretary, Dr. L. Arrieta Sanchez, Apartado No. 86, Panama, R. de P. Meets monthly in a department of radiology of a local hospital, chosen at preceding meeting.

British Empire

Association of Radiologists of the Province of Quebec
Secretary, Dr. Jean-Louis Léger, 1560 Sherbrooke St., Montreal, Que. Meets four times a year.

British Institute of Radiology Incorporated with the Röntgen Society
Ordinary meeting, on the Thursday preceding the third Friday, October to May at 8:15 P.M.
Medical Members' meeting, on third Friday in each month at 5:00 P.M., 32 Welbeck St., London, W 1

Faculty of Radiologists
Honorary Secretary, Dr. R. A. Kemp Harper, 45, Lincoln's Inn Fields, London, W.C.2, England.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

Canadian Association of Radiologists
Honorary Secretary-Treasurer, Dr. D. L. McRae, Suite 305, 1555 Summerhill Avenue, Montreal 25, Que. Meetings January and June.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Société Canadienne-Française d'Electro-Radiologie Médicales
General Secretary, Dr. Ls Ivan Vallée, 1058 rue St-Denis, Montreal 18, Canada. Meets third Saturday each month.
College of Radiologists (Australia and New Zealand)
Honorary Secretary, Dr. Alan R. Colwell, c/o British Medical Agency, 135 Macquarie St., Sydney, N.S.W.

South America

Asociacion Argentina de Radiologia
Secretary, Dr. Lidio G. Mosca, Avda. Gral. Paz 151 Córdoba, Argentina. Meetings held monthly.
Sociedad Argentina de Radiologia, Junta Central, Buenos Aires
Secretary, Dr. Oscar F. Noguera, Santa Fe 1171, Buenos Aires. Meetings are held monthly.
Sociedad Argentina de Radiologia, Filial del Litoral, Sede, Rosario
President, Dr. Francisco P. Cifarelli. Meets monthly second Wednesday, 19 ha 663 Italia St., Rosario, Santa Fe.
Sociedad Argentina de Radiologia, Filial del Sur, Sede, La Plata
President, Prof. Dr. Jose P. Uslenghi, La Plata. Meets monthly.
Sociedad Argentina de Radiologia, Filial del Centro Sede, Córdoba
President, Prof. Dr. David L. Caro, Corro 86, Córdoba. Meets monthly.
Sociedad Argentina de Radiologia, Filial del Norte, Sede, Tucuman
President, Dr. Julio Mendez Valladares, Rivadavia 358, Tucuman. Meets monthly.
Sociedad Argentina de Radiologia, Filial de Cuyo Sede, Mendoza.
President, Dr. J. A. Orfila, Hospital Central, Mendoza. Meets monthly.
Sociedade Brasileira de Radiologia Medica
Secretary, Dr. Nicola Caminha, Av. Mem. de Sa, Rio de Janeiro, Brazil. Meets monthly, except during January, February and March.
Sociedade Brasileira de Radioterapia
Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9:00 p.m. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.
Sociedad Colombiana de Radiologia
Secretary, Dr. Luis E. Lozano B., Carrera 12 No. 20–69, 6° piso, Bogota, Colombia. Meets last Thursday of each month.
Sociedad Ecuatoriana de Radiologia y Fisioterapia
Secretary, Dr. Enrique Ortega Guzmán, Casilla 4719, Guayaquil, Ecuador.
Sociedad Peruana de Radiologia
Secretary General, Dr. Amador Holgado V. Apartado 2306, Lima, Peru. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.
Sociedad de Radiología, Cancerología y Física Médica del Uruguay
Secretary General, Dr. Roberto Francois, Av. Agraciada 1464, Piso 13, Montevideo, Uruguay.
Sociedad Venezolana de Radiología
Secretary, Dr. Otto Paz, Centro Médico, Caracas, Venezuela. Meets monthly third Friday at Colegio Médico del Distrito Federal, Caracas.

Continental Europe

Austrian Roentgen Society
President, Dr. Konrad Weiss, Mariannengasse 10, Vienna 9, Austria. Meets second Tuesday of each month in Allgemeine Poliklinik.
Société Belge de Radiologie
General Secretary, Dr. S. Masy, 256 Chaussée de Wavre, Heverlee-lez-Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.
Société Française d'Electro-Radiologie Médicale, and its branches: Société du Sud-Ouest, du Littoral Méditerranéen, du Centre et du Lyonnais, de l'Ouest, de l'Est, et d'Alger et d'Afrique du Nord
Secretary-General, Dr. A. Dariaux, 9 bis, Boulevard Rochechouart, Paris IX°, France.
Ceskoslovensk společnost pro rëntgenologii a Radiologii v Praze
Secretary, Dr. Roman Bláha, Praha XII, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.
Deutsche Röntgen-Gesellschaft
Secretary, Dr. med. Peter Kröker, Evangelisches Krankenhaus, Huyssens Stiftung, (22a) Essen.
Societa Italiana di Radiologia Medica
Secretary, Prof. Mario Ponzio, Ospedale Mauriziano. Torino, Italy. Meets biannually.
Nederlandse Vereniging voor Electrologie en Roentgenologie
Secretary, Dr. B. J. Rethmeier, Bornsestraat 378, Almelo, Netherlands.
Polish Society of Radiology
Secretary, Dr. Juljusz Borejko, 59 Nowogrodzka St., Warsaw, Poland.
Gdansk Section, Polish Society of Radiology
Secretary, Dr. A. Smigielska, Akademia Lekarska, Gdansk. Meets monthly last Sunday at 10:30, X-Ray Dept., Akademia Gdansk.
Wroclaw Section, Polish Society of Radiology
Secretary, Dr. R. Marciniak, Akad. Medyczna Wroclaw, 68 Curie-Sklodowska St., Wroclaw, Poland. Meets first Sunday of each month, X-Ray Department, Akademia Medyczna Wroclaw.
Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S.I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.
All-Russian Roentgen Ray Association, Leningrad
USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.
Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.
Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.
Schweizerische Röntgen-Gesellschaft (Société-Suisse de Radiologie)
Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern, Switzerland.

India

Indian Radiological Association
Secretary, Dr. R. F. Sethna, Navsari Building, Hornby Road, Bombay 1, India.

The list of Meetings of Radiological Societies is published in every other issue of the Journal.

DAVID ANDERSON-BERRY PRIZE

A David Anderson-Berry Silver-gilt Medal, together with a sum of money amounting to about £100 will be awarded in 1956 by the Royal Society of Edinburgh to the person, who, in the opinion of the Council, has recently produced the best work on the therapeutical effect of x-rays on human diseases.

Applications for this prize are invited. They may be based on both published and unpublished work and should be accompanied by copies of the relevant papers.

Applications must be in the hands of the General Secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh 2, Scotland, not later than March 31, 1956.

LOS ANGELES RADIOLOGICAL SOCIETY

The Eighth Annual Mid-winter Radiological Conference, sponsored by the Los Angeles Radiological Society, will be held at the Biltmore Hotel, Los Angeles, California, on Saturday and Sunday, February 25 and 26, 1956.

Guest speakers will include Dr. R. McWhirter, Edinburgh, Scotland; Dr. Narno Dorbecker, Mexico City, Mexico; Dr. Philip Hodes, Philadelphia, Pennsylvania; and Dr. David Pugh, Rochester, Minnesota.

Reservations may be made through the Conference Secretary, Dr. Norval Zimmerman, 3875 Wilshire Blvd., Los Angeles 5, California. The Conference fee is $20.00, including two roundtable luncheon meetings. The banquet will be $7.00 a plate. Courtesy cards for the Conference are available to residents of radiology and radiologists in military service by advance registration.

Hotel reservations should be made as soon as possible through the Convention Manager, Biltmore Hotel, Los Angeles, California.

COURSE ON CLINICAL USE OF RADIOACTIVE ISOTOPES

A course on the clinical use of radioactive isotopes will be given by Dr. S. Feitelberg and Dr. Edith H. Quimby of the Department of Radiology, Columbia University, New York City. The dates of the course are June 4, 1956 through June 29, 1956, Monday through Friday, 9–12 A.M. and 1–5 P.M. The fee for the course is $200.00.

This is a full-time course which includes lectures, clinical rounds, experimental laboratory exercises as well as clinical laboratory measurements on patients and on specimens. In addition to the listed instructors, sixteen invited lecturers from the New York area will present topics in their special field.

Lectures. Physics of radioactive isotopes and interaction of radiation and matter. Techniques and measurements of radiation and of radioactive isotopes. Clinical use of radioactive iodine in thyroid disease. Therapeutic use of radioactive phosphorus and radioactive gold. Diagnostic use of miscellaneous isotopes (determination of blood volume, localization of brain tumors, radioactive sodium and radioactive iron). Organization of radioisotope work in a hospital.

Laboratory Work. Thirteen afternoon sessions devoted to experiments on Basic methods of radioisotope measurements, on techniques used in clinical diagnostic work and experience with equipment actually used in clinical procedures.

Maximum class, fifteen.

SYMPOSIUM ON FUNDAMENTAL CANCER RESEARCH

The Tenth Annual Symposium on Fundamental Cancer Research will be held on March 29, 30 and 31, 1956 at The University of Texas M. D. Anderson Hospital and Tumor Institute in the Texas Medical Center, Houston, Texas.

A panel discussion on "Nucleic Acid Metabolism in Tumors" will be under the direction of Dr. Van R. Potter, Professor of Oncology at the University of Wisconsin Medical School. Dr. Darrell Ward, Department of Biochemistry, M. D. Anderson Hospital, is in charge of the reports on recent developments in cancer research.

Dr. Grant Taylor, Dean of The University of Texas Postgraduate School of Medicine, is general chairman of the Symposium.

AMERICAN BOARD OF RADIOLOGY EXAMINATIONS

The American Board of Radiology will be conducting three examinations in 1956: (1) Atlanta, Georgia, March 6–10—deadline for filing applications, December 1, 1955; (2) Chicago, Illinois, June 5–9—deadline for filing applications, January 1, 1956; (3) Los Angeles, California, September 30–October 4—deadline for filing applications, June 1, 1956.

B. R. Kirklin, M.D.

TEXAS RADIOLOGICAL SOCIETY SPONSORS LECTURSHIPS

A Visiting Lectureship has been sponsored by the Texas Radiological Society for the three medical schools of Texas: The University of Texas Medical School in Galveston, Baylor University College of Medicine in Houston, and the Southwestern Medical School in Dallas. Guest lecturer for the first group of lectures, to be given in January 1956, will be Dr. Franz Buschke, Seattle. His subject will be "The Role of Common Sense in Cancer Therapy." Further information concerning the date and time of each lecture may be obtained from R. P. O'Bannon, M.D., Fort Worth, Secretary-Treasurer, or Martin Schneider, M.D., Galveston, President.

DEUTSCHE RÖNTGEN-GESELLSCHAFT

As we go to press, we have received a beautiful brochure in honor of the Fiftieth Anniversary of the organization of the Deutsche Röntgengesellschaft (1905–1955). Our congratulations to one of the world's oldest and most honored roentgen ray societies!

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

TUMORS OF THE STOMACH. ATLAS OF TUMOR PATHOLOGY. Section VI—Fascicle 21. By Arthur Purdy Stout, M.D., Professor of Pathology, Columbia University, College of Physicians and Surgeons, New York City. Paper. Price, $1.75. Pp. 104, with 66 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D.C., 1953. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington, D.C.

It is evident from reading Dr. Stout's treatise on gastric tumors that he has a profound understanding of the subject. Of particular value to the radiologist is his discussion of the radiologic features of these tumors correlated with the gross and microscopic pathologic findings. Obviously, the greater portion of the monograph is concerned with carcinoma of the stomach, but all other neoplasms of gastric origin are succinctly described. Color plates and microphotographs accompany the text describing each type of tumor.

This volume, which incidentally can be obtained at a surprisingly low price, should be in the possession of all radiologists, but particularly of those interested in lesions of the stomach.

HAROLD FULTON, M.D.

ATOMIC MEDICINE. Edited by Charles F. Behrens, M.D., Rear Admiral, MC, U. S. Navy, Staff Medical Officer, Eastern Sea Frontier; Formerly: Director, Atomic Defense Division, Bureau of Medicine and Surgery, Navy Department; Commanding Officer, Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland. Second edition. Cloth. Price, $11.00. Pp. 632, with numerous illustrations. The Williams & Wilkins Company, Mt. Royal and Guilford Avenues, Baltimore 2, Maryland, 1953.

As expressed in the preface to the first edition, 1949, the purpose of this book is to present under one cover information on atomic energy pertinent to medicine.

Because of the numerous advances made in the last four years, many of the subjects presented in the first edition have been extensively revised.

The broad scope of this book is evident from the titles of some of the chapters: The Atom Family and Associated Physics, Nuclear Reaction and Atomic Bombs, Fundamental Biology of Ionizing Radiation, The Hematology of Ionizing Radiation, Permissible Dosage and Risk Factors of Ionizing Radiation, Detection and Measurement of Radiation, Survival Methods in Atomic Disaster, Radioactive Isotopes: General Consideration, and Dosimetry and Administration of Radioisotopes.

This book would seem to be of value to those wanting an introduction to the possibilities of atomic energy in medicine.

JOHN H. LAWRENCE, M.D.

TUMORS OF THE RETROPERITONEUM, MESENTERY, AND PERITONEUM. ATLAS OF TUMOR PATHOLOGY. Section VI—Fascicles 23 and 24. By Lauren V. Ackerman, M.D., Professor of Pathology and Surgical Pathology, Washington University School of Medicine; Surgical Pathologist for Barnes Hospital and Affiliated Hospitals, St. Louis, Missouri. Paper. Price, $1.50. Pp. 136, with 105 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D.C., 1954. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D.C.

Primary retroperitoneal neoplasms and tumors of the mesentery and peritoneum are a rather rare group of interest mainly to the surgeon and the radiotherapist. Their correct diagnosis and classification is fraught with

many difficulties, the major of which, in the past, has been a lack of symtematic study of their clinical and pathologic character. Ackerman has attempted in this brief monograph to correct this situation. Although he modestly presents the fascicle as "an introduction to this complex area," careful study of the material contained in its one hundred thirty-six pages will prove worth while to all radiologists, particularly those charged with the problem of radiation therapy of these tumors.

HAROLD FULTON, M.D.

TUMORS OF THE MAJOR SALIVARY GLANDS. ATLAS OF TUMOR PATHOLOGY. Section IV—Fascicle 11. By Frank W. Foote, Jr., M.D. Attending Pathologist, Memorial Center for, Cancer and Allied Disease, New York, New York; and Edgar L. Frazell, Associate Attending Surgeon, Memorial Center for Cancer and Allied Diseases, New York, New York. Paper. Price, $1.50. Pp. 149, with 184 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D.C., 1954. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D.C.

The parotid, submaxillary, and sublingual salivary glands can be the origin of an amazing variety of primary neoplasms. The complexity of the histologic classification of these tumors is appalling and it is fortunate that the authors have undertaken the publication of their experience in this regard in nearly nine hundred cases of primary salivary gland tumor. Using this unparalleled series as a basis for an analysis of the natural history and pathologic features of these tumors, an orderly and complete summary of nearly all known types is presented.

No one seriously interested in the clinical or therapeutic problems evoked by the salivary gland tumors should be without this valuable treatise.

HAROLD FULTON, M.D.

TUMORS OF THE SOFT TISSUES. ATLAS OF TUMOR PATHOLOGY. Section II—Fascicle 5. By Arthur Purdy Stout, M.D., Professor of Pathology, Columbia University, College of Physicians and Surgeons, New York City. Paper, $2.00. Pp. 138, with 78 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D.C., 1953. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D.C.

One need only review the extensive bibliography which is appended to this study of tumors of the soft tissues to realize that Dr. Arthur Purdy Stout is indeed one of the world's authorities on this subject. He has presented a very complete and accurate summary of the clinical and pathologic aspects of tumors of the soft tissues. Indeed, it would be difficult, if not impossible, to find a more comprehensive work on this subject.

Revealing photographs of clinical examples, as well as beautiful color plates and black and white mircoscopic sections, further extend the usefulness of this small volume.

It is highly recommended to all radiologists, but in particular to the radiotherapist who deals more directly with these tumors than the diagnostic roentgenologist.

HAROLD FULTON, M.D.

BOOKS RECEIVED

NINTH ANNUAL REPORT OF THE OAK RIDGE INSTITUTE OF NUCLEAR STUDIES—JUNE 30, 1955. United States Atomic Energy Commission. Paper. Pp. 71, with illustrations. United States Atomic Energy Commission, Oak Ridge, Tennessee, 1955.

EIGHTEENTH SEMIANNUAL REPORT OF THE ATOMIC ENERGY COMMISSION. By United States Atomic Energy Commission, Lewis L. Strauss, Chairman. Paper. Pp. 160, with tables. United States Government Printing Office, Washington, D.C., 1955.

SPEZIELLE RÖNTGENOLOGIE DER LUNGENTUBERKULOSE. By PD. Dr. E. Haefliger. Cloth. Price, DM 52.—. Pp. 322, with 210 illustrations. Benno Schwabe & Co., Basel, Switzerland, 1954.

OPERATIVE CHOLANGIOGRAPHIE; TECHNIK, DIAGNOSTIK, PRAXIS. Von Prov.-Doz. Dr. Walter Hess, Oberarzt der Chirurg. Univ.-Klinik Basel. Cloth. Price $10.00. Pp. 201, with 150 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1955.

ANNUAL REPORT ON THE RESULTS OF TREATMENT IN CARCINOMA OF THE UTERUS. Tenth Volume.

Statement of Results Obtained in 1948 and Previous Years (collated in 1954). Editorial Committee: Dr. J. Heyman (Editor), Stockholm; Dr. M. Donaldson, London; Dr. Joe V. Meigs, Boston; Phil. Dr. C.-O. Segerdahl, Stockholm. Paper. Pp. 345, with numerous tables and illustrations. Editorial Office of Annual Report, Radiumhemmet, Stockholm 60, Sweden, 1955.

Diagnosis of Congenital Heart Disease. By Sven R. Kjellberg, Edgar Mannheimer, Ulf Rudhe, and Bengt Jonsson. Cloth. Price $22.00. Pp. 649, with 581 illustrations. Year Book Publishers, Inc., 200 E. Illinois Street, Chicago 11, Illinois, 1955.

Pädiatrischer Röntgenatlas. Von Dr. M. A. Lassrich, Prof. Dr. R. Prévjt, and Dr. K. H. Schäfer, Hamburg. Cloth. Price, DM 115.—. Pp. 333, with 700 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1955.

La Pneumoginecografia. By F. Marchesi, L. Oliva, V. Albano, M. Maneschi. Paper. Price, L. 1500. Pp. 134, with illustrations. Edizioni Menerva Medica S. A., Torino, Italy.

Symposium on Effects of Radiation and Other Deleterious Agents on Embryonic Development. Sponsored by The Biology Division, Oak Ridge National Laboratory. Paper. Pp. 321, with numerous figures and tables. Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1954.

Symposium on Genetic Recombination. Sponsored by The Biology Division, Oak Ridge National Laboratory. Paper. Free of charge to scientific investigators who can establish a need for this publication. Pp. 321, with numerous figures and tables. Oak Ridge National Laboratory, Post Office Box Y, Oak Ridge, Tennessee, 1955.

Herzkrankheiten im Säuglingsalter. Von Priv.-Doz. Dr. Ettore Rossi, Zürich. Cloth. Price, $15.45. Pp. 373, with 198 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1954.

Studies in Hypertensive Cardiovascular Disease with Special Reference to Cardiac Function. The Scandinavian Journal of Clinical and Laboratory Investigation, Supplement 17. By Edvardas Varnauskas. Pp. 116, with 11 figures and 14 tables. The Scandinavian Journal of Clinical and Laboratory Investigation, Medical Department A., Rikshospitalet, Oslo, Norway, 1955.

Die Bedeutung des Blutchemismus; Besonders in Beziehung zu Tumorbildung und Tumorabbau. Von Prof. Dr. Ernst Leupold, Direktor des pathologischen Instituts der Universität Koln. Cloth. Price, DM 48.—. Pp. 207, with 102 illustrations and 116 tables. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1954.

The Chest; A Handbook of Roentgen Diagnosis. By Leo G. Rigler, M.D., Professor and Chief, Department of Radiology, University of Minnesota. Second edition. Cloth. Price, $8.00. Pp. 380, with 338 illustrations. Year Book Publishers, Inc., 200 East Illinois Street, Chicago 11, Illinois, 1954.

Annual Report on the Results of Treatment in Carcinoma of the Uterus. Eighth Volume. Statements of Results Obtained in 1946 and Previous Years (collated in 1952). By Dr. J. Heyman, Stockholm, Editor; Dr. M. Donaldson, London; Dr. Joe V. Meigs, Boston; Phil. Dr. C.-O. Segerdahl, Stockholm. Paper. Pp. 247, with numerous tables. The Editorial Office, Annual Report, Radiumhemmet, Stockholm 60, Sweden, 1953.

Endemic Goiter; The Adaptation of Man to Iodine Deficiency. By John B. Stanbury, M.D., Gordon L. Brownell, Ph.D., Douglas S. Riggs, M.D., Hector Perinetti, M.D., Juan Itoiz, Ph.D., and Enrique B. Del Castillo, M.D., Cloth. Price, $4.00. Pp. 209, with 53 illustrations and 17 tables. Harvard University Press, Cambridge, Massachusetts, 1954.

Treatment of Toxic Goiter with Radioactive Iodine. By Lindon Seed, M.D., Director, Isotope Laboratory, Grant Hospital, Clinical Associate Professor of Surgery, College of Medicine, University of Illinois; and Theodore Fields, M.S., Assistant Director, Radioisotope Laboratory, Hines Hospital, Instructor in Radiology, Northwestern University Medical School. Fabrikoid. Price, $3.75. Pp. 116, with 17 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1953.

Modern Trends in Diagnostic Radiology (Second Series). Edited by J. W. McLaren, M.A., M.R.C.P., F.F.R., D.M.R.E., Radiologist, X-Ray Department, St. Thomas's Hospital, London; Sometime Examiner in Radiology, University of London. Cloth. Price, $18.00. Pp. 413, with 359 illustrations. Paul B. Hoeber, Inc., 49 East 33rd Street, New York 16, New York, 1953.

Histopathology of the Skin. By Walter F. Lever, M.D., Clinical Associate in Dermatology, Harvard Medical School; Assistant Dermatologist, Massachusetts General Hospital; Associate in Dermatology, Peter Bent Brigham Hospital; etc. Second edition. Cloth. Price, $12.00. Pp. 518, with 281 illustrations, 8 in color. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pennsylvania, 1954.

Vol. 75, No. 1

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

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ROENTGEN DIAGNOSIS

HEAD

MARR, JAMES T. Stone in the maxillary sinus. *Radiology*, May, 1955, *64*, 718–720. (Address: Bowman Gray School of Medicine of Wake Forest College, Winston-Salem, N. C.)

The author reports a case of a stone in the maxillary sinus, adding one to the previously reported 8 cases in the literature. This case, however, is the second one ever to be diagnosed roentgenographically prior to extrusion or removal.

This patient had a tooth extracted 15 years previously and had had a persistent draining fistula ever since. When swelling and pain recurred, the patient sought aid, and roentgenograms of the sinuses demonstrated the stone and thickening of the sinus membrane.

Pervious matter, such as teeth, bone, and tissue fragments, is very likely to perpetuate infection and fistula and less often stone formation occurs. This stone, extracted by the patient, was carefully examined and no nucleus could be found to explain its formation. The patient's symptoms disappeared promptly following removal of the stone.—*Donald N. Dysart, M.D.*

NECK AND CHEST

GARLAND, L. HENRY. (San Francisco, Calif.) Chest Surveys: A symposium. Introduction. *Radiology*, July, 1955, *65*, 19.

Since mass chest surveys have now been conducted for about 20 years, it seems fitting that they should at this time be evaluated as to their true worth. The yield of these surveys has decreased greatly in recent years due either to decreasing morbidity caused by the tubercle bacillus or the increasing resistance of the population.

The question is raised that since these surveys seem to have served their educational purposes, perhaps they should be discontinued . In their place, hospital surveys are probably indicated. How these surveys should be conducted and in what hospitals, and what to expect in the form of side-effects or complications are the points to be discussed.—*Donald N. Dysart, M.D.*

WACHOWSKI, T. J. (Aurora, Ill.) The radiologist and chest surveys. *Radiology*, July, 1955, *65*, 19–22.

The experiences of the author as a radiologist in a 200-bed hospital, where a program existed for roentgenographing the chest of every patient who entered the hospital are related.

A photofluorographic unit was obtained in December 1948, and installed in a combined fluoroscopic-roentgenographic room. Between February 1949 and October 1951, there had been 13,395 admissions. Only 3,476 or about 25 per cent had had chest survey films. Reasons for this poor showing were thought to be: first, the inconvenient location of the equipment, in the Department of Radiology, on the 6th floor of one of the side wings of the hospital. Secondly, the location of the photofluorographic equipment in a combined fluoroscopic-roentgenographic room limited the use of this unit to times when the room was not in use. The third factor has been the shortage of nurses on the hospital floors and since they were responsible for requesting the examination, many patients were dismissed before the survey film was taken.

An Outpatient Chest Service which would roentgenograph the chest on 70 mm. film for 3 dollars of anyone not in the hospital has also been set up, but is not being utilized by the people.

The cost of this chest roentgen ray service program has been 2 dollars per film. This charge was average in 1951, but at present is below actual cost of running it. Compensation for the radiologist varies in different programs from between 10 to 15 dollars per hour, or 10 to 15 cents per film according to a study made by Russell H. Morgan. Since the percentage of errors in diagnosis is higher on the small survey film than on the regular 14 by 17 inch film, it follows that the radiologist reading survey chest films in his private practice would devote more time to a careful consideration of these films to minimize this error. In such a situation it is felt that a charge of around 50 cents apiece for reading these survey films is not only reasonable but is less than the service is worth.

In conclusion, the author states that it is desirable to roentgenograph the chest of every person admitted to a hospital. The filming unit should be in or near the admitting office, and a film should be made immediately upon admittance. If located in the Department of Radiology, the filming unit should be in a separate room. The survey film should not be used for definitive diagnosis or for the recording of the progress of a lesion.—*Donald N. Dysart, M.D.*

BROWN, RAY E. (Chicago, Ill.) The hospital administrator looks at chest surveys. *Radiology*, July, 1955, *65*, 22–24.

Since less than 15 per cent of all hospitals routinely microfilm all admissions, the author has tried to determine the reason for it. He believes that it is up to the medical staff, and the radiologist in particular, since it is in his department, to demand from the administrator and the Board the funds to accomplish this program.

It is felt that the chest surveys yield a higher percentage of results than do many of the other diagnostic tests for which the patient is charged an even larger sum. A charge of 3 dollars for the chest film added to the common first-day routine laboratory fee of 10 dollars should not be too much for the patient to pay. Smaller hospitals without a full-time radiologist should make provisions in the contract

with the radiologist who comes, perhaps once a week, to interpret these chest microfilms.

If the inertia or indifference of the hospital medical staff were overcome, and better cooperation from the prepayment plan organizations were obtained it is felt that many more hospitals would provide this essential service to the hospital patient.—*Donald N. Dysart, M.D.*

Levine, Edwin, R. (Chicago, Ill.) Routine chest films of hospital admissions from the standpoint of the specialist in diseases of the chest. *Radiology*, July, 1955, *65*, 24–25.

The discovery of unsuspected disease in the chest can be considerably enhanced by the routine chest roentgen examination of the hospital patient as well as of the general population. The finding of early tuberculosis, while it is asymptomatic and not communicable, represents the hope of elimination of this disease as it permits early and more satisfactory definitive treatment.

The early diagnosis of bronchogenic carcinoma, possibly only by roentgen examination, permits much better treatment. Other conditions benefited by early diagnosis include mediastinal tumors, emphysema and pulmonary fibrosis. The abnormal heart shadow, mentioned by the radiologist while it is only a slight deviation from normal, alerts the clinician and permits him to study more completely the cardiac status and institute supportive measures.

Diagnoses from these routine chest microfilms are few, but suspicions of the presence of disease followed by recommendations by the radiologist, as to what sort of work-up is indicated by the findings are of immense value to the chest physician. The proper and early establishment of adequate therapy, in almost every instance, can then be undertaken.—*Donald N. Dysart, M.D.*

Buerki, Robin. (Detroit, Mich.) What the public thinks of chest surveys. *Radiology*, July, 1955, *65*, 26–30.

From the layman's view point the chest surveys are an important part of the physician's armamentarium in checking people who think they are well, finding them in good health and keeping them well. This concept is one of positive health.

The finding of disease before it has progressed to the stage where symptoms, minor or incapacitating, bring the patient to the doctor, permits a longer fruitful life for most people instead of a burdensome life for oneself and one's family.

Following this fifth article is a good general discussion by several radiologists who relate their experiences with chest surveys in their hospitals.—*Donald N. Dysart, M.D.*

Norlin, Uno A. T. Traumatic rupture of the main bronchi. *Acta radiol.*, April, 1955, *43*, 305–309. (From: Roentgen Department, Sabbatsberg Sjukhus, Stockholm, Sweden.)

Traumatic rupture of the main bronchi is rare, but should be considered after severe trauma to the chest.

A few cases are recognized early but most are demonstrated post mortem or months or years after the injury. The site of rupture is usually the main bronchus near the carina.

The mechanism of tear apparently depends upon: 1) compression of the bronchus between the chest wall and spine, and 2) increased intrabronchial pressure.

Two cases are discussed and it is suggested that a detailed study of the trachea and main bronchi should be obtained in any case of pneumothorax or mediastinal emphysema following chest injury. The exact diagnosis can be made early in most cases, but if the radiologist fails to demonstrate the rupture, the secondary changes of bronchial occlusion or deformity may always be visualized later.—*Paul W. Mathews, Jr., M.D.*

Harper, Fred R., and Patterson, Lewis T. Osteoarthropathy in carcinoma of the lung. *A.M.A. Arch. Surg.*, May, 1955, *70*, 643–646. (Address: Dr. Harper, Republic Building, Denver, Colo.)

A case is presented and the literature reviewed to call attention to the fact that osteoarthropathy with painful joints and clubbing of the fingers may occur from 2 to 36 months before the classic symptoms and signs of carcinoma of the lung occur.—*James J. McCort, M.D.*

Woolley, Paul V., Jr. Grass inflorescences as foreign bodies in the respiratory tract. *J. Pediat.*, June, 1955, *46*, 704–706. (From: Department of Pediatrics, Wayne University College of Medicine, and Children's Hospital of Michigan, Detroit, Mich.)

Three cases of "timothy grass pneumonia" are presented. This condition results from the aspiration of the spikes of the common timothy or fox-tail grasses and is manifest roentgenographically as a chronic inflammatory infiltration in the involved segment of the lung. The spikelets on the heads of these grasses tend to prevent their being coughed out and probably are also responsible for some degree of peripheral migration within the bronchial tree.

The cases presented point up the seasonal incidence of this condition; each child became ill in July when these grasses reach maturity. In two of these patients the grass foreign bodies were removed bronchoscopically, from one after about two months and from the other not until 12 months after the

aspiration had occurred. While both of these patients have done well since, they have continued to show evidence of bronchiectasis and fibrosis in the involved segment of the lung. In the third patient the foreign body could never be visualized by bronchoscopy and a chronic pneumonia persisted for three years at which time a lobectomy was performed and a fully preserved spike of timothy grass was found in the removed tissue.

These cases indicate the benefits to be derived from early suspicion of the possibility of aspiration of these grass spikes and from their early removal before they have a chance to work themselves more peripherally into the bronchial tree beyond reach of the bronchoscope.—*H. G. Peterson, Jr., M.D.*

Gianturco, Cesare, and Miller, George A. Bilateral bronchography; new material and technic. *Radiology*, July, 1955, *65*, 57–60. (From: Section on Diagnostic Roentgenology, Carle Hospital Clinic, Urbana, Ill.)

Dionosil oily, a 50 per cent suspension of the crystals of n-propyl ester of 3:5-diiodo-4-pyridone-N-acetic acid in arachis oil, has been used by the authors in 25 bilateral bronchograms with favorable results. It was found that the opacity caused by this new medium is similar to that of the iodized oils, and has the advantage that it is absorbed in from three to five days.

The injection of dionosil oily is no more irritating than that of iodized oil and requires no more anesthetic. It does not penetrate the terminal bronchioles nor the alveoli, perhaps because of the size of the crystals. Most of the material is expelled by coughing, while that portion remaining is absorbed after hydrolyzation without liberation of free iodine. This makes it possible to employ dionosil even in iodine-sensitive patients.

The technic of bilateral bronchography can be facilitated by the simultaneous filling of all the bronchi of each side. This is done by injecting a measured amount of contrast material through an intratracheal catheter as rapidly as possible (in four to six seconds), in lateral decubitus, with the patient tilted upward about 10 degrees. This rapid injection is dangerous if the catheter tip is lodged in one of the minor bronchi, so it is important that the tip of the catheter be placed about 2 cm. above the carina.

The purpose of the rapid injection is to fill the dependent main bronchus and cover the mouths of all of its branches at once. If this is done, the opaque medium is aspirated toward the periphery and attains a uniform distribution throughout the bronchial tree. The total amount of opaque material varies from 8 to 20 cc. per side. After a rapid fluoroscopic check, additional material may be injected in localized areas, if needed.

The rapid injection technic may be used with any contrast medium. Even when iodized oils are employed, alveolar filling and subsequently "lung stain" are reduced to a minimum. An intratracheal catheter is essential for this method of injection. Of aid to the radiologist in the introduction of the catheter is a special instrument which is described.

The technic described in this article and the use of dionosil oily, have, according to the authors, made complete bilateral bronchography a relatively simple and reliable procedure.—*A. Ralph Watson, M.D.*

Géher, F. Bei der Aluminiumherstellung auftretende Lungenveränderungen. (Pulmonary changes in aluminum workers.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, May, 1955, *82*, 598–604. (From: Röntgenklinik der Medizinischen Universität, Budapest, Hungary.)

Pulmonary aluminosis was observed after inhalation of aluminum containing ores (bauxite, argillaceous earth and cryolite) as well as pure aluminum. The importance of these observations is obvious considering that inhalation of hydrated alumina has been advocated in the treatment of silocosis.

Experiments showed that aluminum in powder form is ionized in 1 per cent saline solution and that aluminum ions precipitate proteins.

The pathologic changes consist in formation of fibrous tissue with induration and retraction and basal emphysema.

The complaints consist in cough with scant sputum, stabbing chest pain, dypsnea and night sweats. Often there are loss of appetite, weight loss and indefinite gastrointestinal complaints.

The following roentgenological findings have been described previously: increased linear lung markings in the upper and middle fields with basal emphysema and ill-defined sometimes confluent zones of consolidation. Pleuropericardial and mediastinal adhesions were frequent. Spontaneous pneumothorax was likewise a frequent complication.

The author examined over 1000 workers exposed to dust containing bauxite, argillaceous earth and cryolite. No cases of exposure to pure aluminum were observed.

Abnormal roentgenological findings were noted in 3.5 per cent of bauxite workers, 4.9 per cent of workers exposed to inhalation of argillaceous earth and in 6.3 per cent of workers in aluminum shelters exposed to argillaceous earth and cryolite.

Two distinct types were observed by the author: 1. Discrete increase in lung markings, uni- or bilateral, in the middle or lower lung fields, with pinhead sized interspersed nodules. Minimal pleural adhesions and decreased excursions of the diaphragms were occasionally noted. 2. Ill-defined confluent small zones of consolidation, more often unilateral, forming a shadow the size of a child's palm, usually in the middle or lower lung field, with increased lung markings extending to the hilus. The

hilus was not enlarged. Pleural adhesions and decreased diaphragmatic mobility were frequent.

The time interval from onset of exposure to dust was 2 to 9 years in the first group and 3 to 7 years in the second. No progress in the pulmonary changes was noted on subsequent examinations within a 2 year period. No active pulmonary tuberculosis was observed in the cases of aluminosis. The patients with aluminosis were not significantly incapacitated. This article is illustrated by 5 roentgenographic reproductions and contains fairly numerous references, mainly from continental sources.—*Karol E. Matzinger, M.D.*

DiCara, Leo V. A rare case of spontaneous hemothorax. *Am. Rev. Tuberc. & Pulmonary Dis.*, May, 1955, *71*, 755–761. (From: Veterans Administration Hospital, Tucson, Arizona.)

A case of spontaneous hemothorax in a patient with thrombocytopenic purpura and pulmonary tuberculosis is reported. The etiology is usually due to a rupture of an adhesion or bullae necessarily involving vascular channels. A detailed account of the clinical and laboratory findings is given.—*C. Peter Truog, M.D.*

Wigh, Russell, and Montague, Eleanor D. Evaluation of intrapulmonic adenopathy in sarcoidosis. *Radiology*, June, 1955, *64*, 810–817. (From: Department of Radiology of the College of Physicians and Surgeons, Columbia University, and Radiological Service of the Presbyterian Hospital, New York, N. Y.)

In the differential diagnosis of intrathoracic lymph node enlargement in adults, the possibility of sarcoidosis and the malignant lymphomas must be considered. In an attempt to establish roentgen criteria to separate the above two diseases, 50 cases of well substantiated sarcoidosis with intrathoracic adenopathy were studied along with the charts of 128 consecutive lymphosarcoma patients and 55 cases of Hodgkin's disease, of which 42 had intrathoracic lymph node enlargement.

Their studies revealed that the intrapulmonic lymph nodes, those located near the angles of the division of the bronchi, arteries or veins, were enlarged in 40 of the 50 cases of sarcoidosis, while only 11 of the 42 cases of the lymphoma group showed enlargement of these lymph nodes. These enlarged lymph nodes are best visualized along the course of the right descending pulmonary artery—the left lung being obscured by the heart.

No case of sarcoidosis was encountered in which bilateral mediastinal widening was present without intrapulmonic adenopathy, while such a situation is frequent in lymphomas. Enlarged anterior mediastinal lymph nodes with no enlargement of the intrapulmonic lymph nodes makes the diagnosis of sarcoidosis extremely unlikely.

The typical pattern of adenopathy in sarcoidosis is represented by the combined enlargement of intrapulmonic and hilar lymph nodes and the absence of anterior mediastinal adenopathy. This pattern is infrequent in the lymphomatous neoplasms.—*Donald N. Dysart, M.D.*

Abrams, Herbert L. Radiologic aspects of operable heart disease. I. Observations on the preoperative approach to congenital anomalies. *Radiology*, July, 1955, *65*, 31–49. (From: Department of Radiology, Stanford University School of Medicine, San Francisco, Calif.)

The author presents a list of cardiac anomalies amenable to surgery, and discusses a number of these conditions emphasizing particularly the roentgenologic aspects of the diagnosis. The congenital cardiac anomalies are divided into acyanotic and cyanotic groups, and a table of differential diagnostic data is given.

The importance of proper evaluation of clinical, laboratory, and roentgenological data is clearly shown. This point is particularly brought out in dicussion of a patient who had pulmonic stenosis with pulmonary plethora. In this instance, cardiac catheterization was essential in the making of a correct diagnosis. In the diagnosis of atypical patent ductus arteriosus, retrograde brachial aortography often proves the simplest and most accurate method available. By this method one can usually differentiate accurately between patent ductus and other conditions such as intracardiac shunts. Angiocardiography, and evaluation of findings from physical examination, routine fluoroscopy, and electrocardiographic patterns will often serve to adequately diagnose the "reverse ductus."

It is, of course, well known that coarctation of the aorta is often surgically correctable, and excellent response to surgery may be anticipated. Retrograde brachial aortography here again is an invaluable aid. One condition to be considered in the differential diagnosis is endocardial fibroelastosis, which can often simulate coarctation, and is not correctable by surgery.

Among the cyanotic anomalies with decreased pulmonary blood flow, it is important to distinguish between the tetralogy of Fallot in which overriding is present, and pulmonic stenosis with patent foramen ovale, since in the latter a direct surgical attack on the valve is indicated, and a Blalock-Taussig operation is contraindicated. Other conditions discussed include tricuspid atresia downward displacement of the tricuspid valve (Ebstein's anomaly) and anomalous pulmonary veins. Note is made of the figure of eight shadow often seen in the latter condition.

Since the list of cardiac anomalies amenable to surgery is growing longer, one is impressed with the

magnitude of the responsibility of the diagnostic team. In the final analysis, the roentgenologic data may be the single most important factor in determining whether a case is suitable for operation.—*A. Ralph Watson, M.D.*

McCORD, MALCOLM C., and BLOUNT, S. GILBERT, JR. Complications following infundibular resection in Fallot's tetralogy. *Circulation*, May, 1955, *11*, 754–760. (From: Cardiovascular Laboratory, University of Colorado School of Medicine, Denver, Colo.)

The authors report 2 unusual complications following surgery in cases of tetralogy of Fallot. In the first case a four year old boy was operated upon and an incision was made through the infundibular chamber exposing a localized stenotic ring at the pulmonic valve. The ring was excised without closure of the interventricular defect. Postoperatively, the patient did well for a short time, but seven weeks later he developed a large aneurysm of the infundibular chamber which the authors believe developed as the result of the elevated right ventricular systolic pressure and increased blood flow. It is suggested that the aneurysm developed because of the abrupt change in hemodynamics.

A twelve year old boy was operated upon for infundibular stenosis. After the stenosis was repaired, the patient improved symptomatically for a time, but it was found that he had developed a left to right shunt through the interventricular defect. This was followed by dilatation and hypertrophy of the left ventricle and by increase in pulmonary blood flow and dilatation of the pulmonic valve causing functional pulmonic insufficiency. The authors feel that the operation in addition to correction of the infundibular stenosis created a dynamic artificial clinical picture of a large ventricular defect and they plan to carry out additional operative repair.

The authors point out that considerable surgical judgment is required in order to determine the precise extent of infundibular resection that will result in a beneficial degree of increased pulmonary blood flow. It is expected that future techniques will permit simultaneous correction of valvular stenosis and ventricular defects.—*C. L. Hinkel, M.D.*

NICE, CHARLES M., JR., and HALL, C. WILLIAM. The relationship of the left atrium to the opacified esophagus in upright and recumbent positions. *Radiology*, July, 1955, *65*, 61–64. (From: Department of Radiology, University of Minnesota Medical School, Minneapolis, Minn.)

It has long been recognized that the close apposition of the posterior surface of the left atrium to the anterior wall of the thoracic esophagus is of diagnostic significance in evaluating enlargement of this cardiac chamber.

Mitral valvular disease is the most common cause of left atrial enlargement, but dilatation of the left ventricle, auricular fibrillation, patent ductus arteriosus, and interventricular septal defect may produce functional changes which enlarge the left atrium. With these conditions, however, atrial enlargement is not always sufficient to produce esophageal deviation in the upright patient. It has been stated that lesser degrees of enlargement may become manifest with the patient prone, since in this position the venous return is increased and the left atrium is filled to its fullest extent.

Since it seemed to the authors that relatively little investigation had been carried out to determine whether changing position affects the relationship of the left atrium and the opacified esophagus in normal individuals, a study of one hundred normal young adults was carried out. In this study, examinations were made in the upright, prone, and lateral recumbent positions. It was found that only three subjects revealed appreciable localized esophageal deviation in the upright position, and the authors concluded that such a change could be considered strong presumptive evidence of enlargement of the left atrium.

Since 38 individuals showed more than equivocal displacement of the esophagus in the prone position, and 48 individuals showed more than equivocal displacement in the right lateral recumbent position, it was considered doubtful whether any deviation unless of extreme degree, should be considered significant if the examination was done in the horizontal position.

The phase of respiration has also been said to affect the relationship of the left atrium with the esophagus. In order to study this hypothesis, three groups of five normal individuals each were examined, comparing esophageal deviation in inspiration and expiration, and utilizing upright, prone and right lateral recumbent positions. There was found to be a definite tendency to slight deviation in expiration where none was present on inspiration.

The authors also point out that the degree of left atrial enlargement is not related to the severity of the mitral lesion, and that a patient with severe stenosis of the mitral valve may be seen at a time when only slight left atrial enlargement is apparent. —*A. Ralph Watson, M.D.*

EYLER, WILLIAM R., ZIEGLER, ROBERT F., SHEA, JAMES J., and KNABE, GEORGE W. Endocardial fibroelastosis: Roentgen appearance. *Radiology*, June, 1955, *64*, 797–809. (From: Henry Ford Hospital, Detroit, Mich.)

Endocardial fibroelastosis is a condition in which there is thickening of the endocardium due to a heavy layer of elastic and collagen fibers which may extend into the myocardium for short distances about the small blood vessels. The left side of the heart is most often affected, chiefly the ventricle.

Cardiac hypertrophy and dilatation are usually quite marked. This disease is most commonly seen in infants and children, but has been found in adults, and in the earlier ages is thought to be developmental.

Typically, it is present in endocardium poorly nourished because of anomalies of the coronary circulation and in hearts subject to abnormal stresses because of some mechanical or structural defect. Clinically, the patients present various manifestations of cardiac failure. Routine physical or roentgenologic examination discloses an enlarged heart. Roentgenographically, when the heart is compensated, a normal pulmonary circulation will be evident, but with failure congestive changes will appear. A globular shaped heart is often seen in infants, while ventricular enlargement is observed in older patients. Heart catheterization studies will rule out any of the potentially operable cardiovascular defects as well as other anomalies and defects.

The differential diagnosis of the cardiac enlargement following the complete studies includes the "primary myocardial diseases," namely endocardial fibroelastosis, glycogen storage disease, idiopathic myocarditis, medial necrosis of coronary arteries, tumors of the heart, and origin of the left coronary from the pulmonary artery. The final diagnosis is usually made after autopsy study.

The authors present 9 case reports illustrating this disease.—*Donald N. Dysart, M.D.*

Knutsson, Folke. The mediastinal pleura. *Acta radiol.*, April, 1955, *43*, 265–275. (From: Roentgen Department, University Hospital, Upsala, Sweden.)

Roentgen diagnostic studies in the living subject have often resulted in a reassessment of the textbook knowledge of descriptive and topographic anatomy. Erroneously, based on cadaver investigations, the latter have often been taken to correspond to conditions in true life. There is room for reappraisal of our textbooks of anatomy with greater stress on the discrepancies between the living subject and the cadaver.

According to textbooks of anatomy the mediastinal and the costovertebral pleurae meet to form a straight line along the lateral borders of the vertebral bodies. The posterior mediastinum is described as a wide space with the aorta and esophagus anterior to the vertebral bodies.

With conventional roentgenography it has been possible to show, to a limited degree, the incidence, depth and extent of pleural recesses in the posterior mediastinum in the living subject. By means of laminagraphy we are now better able to study the living subject in comparison with the cadaver. Frontal laminagraphy of the posterior mediastinum at the level of the tracheal bifurcation and below, reveals a width less than 2 cm. This is appreciably less than on the cadaver. Furthermore, the posterior mediastinum is slightly to the left of the midline.

Transverse laminagraphy at the hilar level demonstrates a relatively great distance between the vertebral bodies and the esophagus. The distance varies in different subjects. The space between the heart and vertebral column is uniformly filled with air (lung). A line along the right border of the sternum marks the junction of the right mediastinal and costal pleurae. On the left side it forms a lateral convex bulge at the level of the 5th and 6th costal cartilages. Great individual variations occur and similarly the course of the anterior border of the lung varies. The area of absolute cardiac dullness is not constant.

With the use of conventional roentgenographic technic and laminagraphy it is possible to study anatomy in the living subject and to determine the differences between it and the cadaver. A knowledge of normal roentgen anatomy is essential for the recognition of the pathological. Therefore, an acquaintance with the course of the mediastinal pleura is a prerequisite to the recognition of pathological conditions. It is important to remember that the right lung bulges into the mediastinal-vertebral recess anterior to the vertebral column. Hence, the difficulty of recognizing disease in the lung at this level, which is obscured by the spine.

Eleven reproductions of roentgenograms accompany this excellent article.—*William H. Shehadi, M.D.*

Levin, Bertram. On the recognition and significance of pleural lymphatic dilatation. *Am. Heart J.*, April, 1955, *49*, 521–537. (From: Department of Diagnostic Roentgenology, Michael Reese Hospital, Chicago, Ill.)

A frequent finding in chest roentgenograms of patients with mitral stenosis consists of short transverse lines of increased density in the bases of the lungs. The lines are approximately two or three centimeters long and extend outward to the pleural surface and are arranged in parallel fashion, one above another.

Levin believes that these lines may represent the interlobular lymphatics which run at right angles to and connect with the pleural lymphatics. The roentgen appearance of dilatation of these pleural lymphatics is highly characteristic, but differentiation from "discoid" or "plate like" atelectasis, which occurs in similar areas of the lung, must be made. The lesions of "plate-like" atelectasis usually appear as single lines though on occasion two or three may be present; they never appear in as large numbers as do the basal striae of lymphatic dilatation and rarely assume the parallel transverse arrangement. Furthermore, Fleischner's lines do not originate in the periphery of the lung to extend to the pleural surface as do the striate dilated lymphatic channels. Pulmonary

arterial dilatation, venous congestions, and peribronchial thickening can all be differentiated from pleural lymphectasia since the latter shows none of the typical vascular or bronchial arborization, nor do the lymphatic channels diminish in caliber as they extend peripherally.

In an attempt to correlate the presence of dilatation of the pleural lymphatics, with pulmonary arterial hypertension, the chest roentgenograms of 63 patients with the clinical diagnosis of mitral stenosis were studied in relation to cardiac catheterization data. Pulmonary arterial and pulmonary wedge pressures were found to be significantly higher in the group of patients with basal lymphatic striae than in those without striae. Mitral commissurotomy with subsequent relief of pulmonary hypertension in these cases often caused the lymphectasia to decrease or disappear.

In some cases of chronic sustained elevation of pulmonary venous pressure due to left ventricular failure, dilatation of pleural lymphatics may be present. It is of interest to note, however, that in 20 patients with congenital heart disease exhibiting marked pulmonary hypertension dilatation of the pleural lymphatics, was universally absent.

It is concluded that the roentgen appearance of dilatation of the pleural lymphatics is characteristic and when noted, mitral stenosis with chronic pulmonary venous and arterial hypertension can be diagnosed with reasonable certainty.—*Harold Fulton, M.D.*

LYONS, HAROLD A., and STOREY, CLIFFORD F. The problem of mediastinal tuberculosis. *Am. Rev. Tuberc. & Pulmonary Dis.*, May, 1955, *71*, 635–667. (Present Address: Dr. Lyons, Department of Medicine, State University of New York, College of Medicine, New York, N. Y.)

The authors discuss the clinical manifestations, the diagnostic features and the treatment of tuberculous lesions of the mediastinum. The clinical picture produced by mediastinal tuberculosis depends upon which of the anatomic structures is affected. During its active granulomatous inflammatory reaction or by its healing proliferative process, mediastinal tuberculosis may involve (1) the tracheobronchial air passages, (2) the esophagus, or (3) the mediastinal vascular structures.

The bronchus to the right middle lobe is more subject to compression by enlarged lymph nodes and is narrower than any other lobar bronchus. The key node is on the inferior surface of the bronchus. The term "middle lobe syndrome" has been used to denote this condition. In the experience of the authors, the lateral segment is the one most frequently atelectatic.

In children with primary tuberculosis, the lymph nodes may become enlarged and produce bronchial compression. Actual erosion into the lumen of the bronchus may occur. Bronchial obstruction is the primary factor in producing suppurative disease, especially bronchiectasis.

The symptoms in the patients with tuberculosis of the mediastinum may assume one or more of the following forms: Chronic cough, recurrent hemoptysis, general debility, chest pain, a single acute pneumonic episode, recurrent febrile episodes or a clinical picture simulating bronchogenic carcinoma. The presence of antecedent pleural effusion is helpful in suggesting tuberculosis. Hemoptysis is a frequent symptom. The demonstration of carbon particles in the sputum is significant of tuberculous lymph node erosion of a bronchus.

Roentgenographic examination of the chest is very important and the findings usually suggest the nature of the disease. Posterioanterior and lateral views will disclose the presence of atelectasis and its extent, as well as an emphysema, if present. Films in the lordotic position are valuable for diagnosis of middle lobe involvement.

Bronchoscopy should be done in every case because of its therapeutic value as well as its diagnostic importance. Bronchography is indicated in most cases.

The differential diagnosis is concerned with foreign body, bronchogenic carcinoma, bronchial adenoma, bronchiectasis, cholesterol pneumonitis, and primary pulmonary abscess.—*J. N. Ané, M.D.*

ELLIS, F. HENRY, JR., KIRKLIN, JOHN W., HODGSON, JOHN R., WOOLNER, LEWIS B., and DUSHANE, JAMES W. Surgical implications of the mediastinal shadow in thoracic roentgenograms of infants and children. *Surg., Gynec. & Obst.*, May, 1955, *100*, 532–542. (From: Sections of Surgery, Roentgenology, Surgical Pathology, and Pediatrics, Mayo Clinic and Mayo Foundation, Rochester, Minnesota.)

The authors have reviewed the case of patients under fifteen years of age whose roentgenograms showed evidence of mediastinal tumors at the Mayo Clinic. There were 98 such cases between January, 1935, and December, 1953. Primary mediastinal cysts or tumors other than lymphoma accounted for 45 of these. These were proven by biopsy. They were divided as follows: teratomatous tumors, 31 per cent; neurogenic tumors, 31 per cent; enterogenous cysts, 13 per cent; cystic hygromas, 9 per cent; vascular tumors, 9 per cent; and unclassified malignant tumors, 7 per cent.

Forty-three of these were diagnosed by thoracotomy and 2 by necropsy. All 14 teratomas were removed surgically with one operative death. Typically, these were in the anterior mediastinum.

Nine of the 14 neurogenic tumors were ganglio-

neuromas arising from the sympathetic nerves. All were in the posterior mediastinum.

Three of the enterogenous cysts were bronchogenic cysts, 1 an esophageal cyst and 1 a gastric cyst. They usually lie in the mid mediastinum.

The authors give the usual differential diagnoses for the tumors and include non-neoplastic shadows such as those produced by the thymus gland.

Twenty per cent of the tumors were found to be malignant. This does not include lymphomas or metastatic neoplasms. Because of the high incidence of malignancies, they stress the importance of accurate diagnosis including thoracotomy when other methods are inadequate.—*Frank M. Windrow, M.D*

Stewart, John D., Chardack, William M., and Alfano, Guy S. Reflux esophagitis. *Ann. Surg.*, May, 1955, *141*, 627–636. (From: Departments of Surgery of the Edward J. Meyer Memorial Hospital and Buffalo Veterans Administration Hospital, Buffalo, New York.)

The authors discuss 66 cases of reflux and peptic esophagitis which they have studied in the past five years. In 42 of these patients a sliding hiatal hernia was found, and 28 of the 66 had clinical data suggesting that duodenal ulcer was or had been present.

Symptoms commonly encountered were heartburn, retrosternal distress, dysphagia, regurgitation of food and bleeding into the upper gastrointestinal tract. Pathologic changes produced by prolonged reflux of gastric juice in the presence of an incompetent cardio-esophageal sphincter or regurgitation of the upper intestinal juices into lower esophagus after esophagojejunostomy include diffuse inflammation of the lower esophagus, erosion, ulceration and scarring.

Peptic esophagitis occurring in the absence of gastric reflux is based on malposition of gastric mucosa, so that activated gastric juice is secreted directly into the lumen of the esophagus. This type as seen in infancy and childhood, may occur with the stomach in normal position or without hiatus hernia, and in such cases, the lower esophagus may be lined with a continuous sheet of gastric mucosa.

It is well known that not all patients with hiatal hernia and gastric reflux develop progressive esophagitis. In those who do the esophagus may become shortened, stenotic, and the cardio-esophageal junction fixed in the mediastinum. This results in a serious surgical problem, particularly as the event which brings the patient to surgery is either severe hemorrhage or esophageal obstruction. Evidence of progression of reflux esophagitis is an indication for prompt surgical treatment.

Definitive surgery was carried out thirty-two times in this series of cases, the other patients being carried on a medical regimen, with dilatations if necessary. The most satisfactory surgical plan appears to be resection of as much of the proximal stomach as possible, and yet leave enough distal stomach to bring into the chest for esophageal anastomosis. A pyloroplasty is added to promote rapid gastric emptying. A satisfactory solution to the problem of esophageal reconstruction after resection for stenosing esophagitis has not yet been found.—*Arthur B. Smith, M.D.*

Johnstone, A. S. Oesophagitis and peptic ulcer of the oesophagus; The Mackenzie Davidson Memorial Lecture. *Brit. J. Radiol.*, May, 1955, *28*, 229–240. (Address: Department of Radiodiagnosis, University of Leeds, Leeds, England.)

For over a century the pathologists have recorded peptic ulcers of the esophagus and esophagitis but not until recently have these conditions become recognized as clinical entities. These two conditions have a common etiological factor, namely, reflux of acid pepsin, but have a different morbid anatomy as well as clinical and roentgenological features.

Distinction is made between the "circumscribed" peptic ulcer and diffuse superficial inflammation of the esophagus with patches of healing intermingled with areas of erosion or superficial ulceration.

Our knowledge about reflux esophagitis, the more common of the two conditions, has come chiefly through improved esophagoscopy and roentgenologic examination. The segment involved varies between 1–2 cm. to a maximum of 7–8 cm. Healing may result in permanent stenosis. The circumscribed peptic ulcer, "gastric ulcer" type, is usually near the cardia where gastric mucosa may be present. These ulcers tend to be single and spread longitudinally. The more frequent complications leading to death are perforation into a large vessel, the lungs, pleura or mediastinum. Obstruction is a rare sequela.

Nature has provided a complex mechanism at the esophagogastric junction which allows food, fluid and air to enter the stomach and prevents their backflow. This includes pressure changes in the thorax and abdomen during respiration, coughing and straining. This mechanism is adaptable as it permits belching and vomiting. However, long-standing disruption of this mechanism results from or accompanies anatomical defects, hiatus hernia, pregnancy with repeated vomiting and regurgitation, increased intra-abdominal pressure, increased adiposity and disturbed anatomical relationship following surgery with traction on the esophagus. Under these conditions repeated acid pepsin reflux will produce the above listed pathological changes in the esophagus. An incidence of 75 per cent esophagitis is reported in a series of sliding esophageal hernias.

Roentgenologically, the mucosa is demonstrated as irregular, swollen and granular in appearance. Slight narrowing due to spasm is noted early and

eventually stenosis may result. The presence of a crater is diagnostic of a peptic ulcer.

The author makes a plea for more careful study of the lower esophagus in an effort to better evaluate pathological conditions at this level, especially as a cause of anginal attacks through vasovagal reflex, as well as to further clinical and scientific investigations of this area since a great many questions remain unanswered.

Twenty-nine reproductions of roentgenograms and sketches accompany this article.—*William H. Shehadi, M.D.*

ABDOMEN

CANADA, WILMA J. Use of Urokon (sodium-3-acetylamino-2,4,6-triiodobenzoate) in roentgen study of the gastrointestinal tract. *Radiology*, June, 1955, *64*, 867–873. (From: Department of Radiology, Massachusetts General Hospital, Boston, Mass.)

Because of the danger of obstruction and inspissation of barium in intestinal fistulas or abscess cavities, the author investigated the use of urokon (sodium-3-acetylamino-2,4,6-triiodobenzoate) in a 30 per cent solution for these procedures.

The main advantage of urokon over barium is that because it is a thin liquid it penetrates small tracts and cavities readily and does not become inspissated. It also disappears rapidly from fistulas and abscess cavities, presumably by absorption or diffusion. This allows subsequent examinations without interference by residual contrast medium. In the study of ulcerative colitis, especially with defunctioned colons, it proved quite adequate.

Fluoroscopic visibility and film opacification were less than with barium, but compensation for this was apparently met satisfactorily. Absorption of the medium was evidenced in 4 of the 13 patients studied by the appearance of faint or distinct pyelograms a short time after administration, but no ill effects were noted. In upper intestinal tract examinations the medium has to be introduced through a tube because of the bitter taste.

From a commercial standpoint the expense of an examination with urokon is high because of the large quantities necessary. The small ampules also present an inconvenience. The suggestion is made that less expensive bulk material which need not be sterile be made available.—*Donald N. Dysart, M.D.*

POPPEL, MAXWELL, H., ZAINO, COSTANTINO, and LENTINO, WALTER. Roentgenologic study of the lower esophagus and the esophagogastric junction. *Radiology*, May, 1955, *64*, 690–700. (From: Department of Radiology of New York University College of Medicine and the Radiology Service of Bellevue Hospital Center, New York, N. Y.)

A roentgenologic study of the lower esophagus by means of the "oil contrast" polygraph technic as well as by the conventional routine method was made in 500 unselected cases. The oil contrast method revealed positive findings in 67, and a complete follow-up was obtained in 54 of these. Of the 54 patients, 41 had abnormalities which were overlooked in the conventional examination.

The roentgen anatomy of the lower esophagus and esophagogastric junction is best demonstrated by the oil contrast polygraph technic. The phrenic ampulla is a physiological dilatation of the lower esophagus which is separated from the gastroesophageal vestibule by a narrowing at its base produced by the inferior esophageal sphincter. This narrowing is seen 1 to 3 cm. above the diaphragm when the esophagus is full during forced inspiration. The gastroesophageal vestibule corresponds to the abdominal esophagus and extends from the inferior esophageal sphincter to the constrictor cardiae, the narrowing at the junction of the esophagus and stomach. The phrenoesophageal membrane arises from the pillar and fascia of the diaphragm and divides into an ascending portion, anchored at the level of the inferior esophageal sphincter, and a descending portion attached to the muscular coat of the cardia of the stomach. It resists excessive shortening of the esophagus and allows for free mobility of the esophagus during respiration. The esophageal diaphragmatic hiatus is a gap in the medial fibers of the right crus of the diaphragm.

Hiatal insufficiency and eventually hiatus hernia may result if the phrenoesophageal membrane is defective or unusually thin, or if the esophageal hiatus is unusually wide. In sliding or concentric hiatus hernia the underlying weakness is probably a defective phrenoesophageal membrane while in paraesophageal hernia the underlying defect is probably a large esophageal hiatus. The most important roentgen finding in sliding hiatus hernia is a persistent small pouch in which gastric mucosal folds are demonstrated above the diaphragm with the esophagus entering at its apex and showing a localized constricted area for about 1 cm. above this junction probably due to the still present attachments of the uprooted phrenoesophageal membrane. In paraesophageal hiatus hernia roentgen examination shows a persistent small pouch containing gastric mucosa to one side of the esophagus above the diaphragm. A characteristic and diagnostic "double ring" shadow may be produced by the protrusion of a knuckle of fundus or cardia through the esophageal hiatus with superimposition of a dilated or filled gastroesophageal vestibule.—*Harold C. Hamilton, M.D.*

SILVERMAN, FREDERIC N. Gastroesophageal incompetence, partial intrathoracic stomach, and vomiting in infancy. *Radiology*, May, 1955, *64*, 664–674. (From: Departments of

Radiology and Pediatrics, College of Medicine, University of Cincinnati; The Children's Hospital and The Children's Hospital Research Foundation, Cincinnati, Ohio.)

Two conditions causing persistent vomiting in infancy are cardioesophageal relaxation or chalasia and partial intrathoracic stomach. The recognition of both conditions depends on the observation of abnormal flow of contrast substance from the portion of the foregut below the diaphragm into the portion above the diaphragm. The differentiation of the two conditions depends on identification of the cardioesophageal junction, as well as its location in an abnormal position, which is subject to considerable error by any single technic. Although identification of the cardioesophageal junction roentgenographically by demonstration of a change in the mucosal pattern has been regarded as highly reliable, it has been shown that transverse mucosal folds in the lower esophagus may occur under conditions of contraction of longitudinal musculature and easily simulate gastric mucosa. Clear differentiation between the two conditions is not always possible and certain similarities suggest that they may be identical, if not different stages of the same disease.

The condition previously known as congenital short esophagus probably does not exist as an entity, but represents shortening due to cicatricial contraction of a chronically inflamed esophagus irritated by the reflux of acid gastric contents.

The method of choice in the treatment of gastroesophageal incompetence in early infancy is postural treatment with maintenance of the infant in an erect position.—*Harold C. Hamilton, M.D.*

Zaino, Costantino, Poppel, Maxwell H., and Blazsik, Charles F. Roentgenologic study of the abdominal segment of the esophagus in the presence of pneumoperitoneum. *Am. J. Digest. Dis.*, May, 1955, *22*, 121–128. (From: Departments of Radiology of the New York University of College of Medicine and St. Anthony's Hospital, Woodhaven, Long Island, N. Y.)

To enhance the knowledge of the normal roentgenologic anatomy of the abdominal esophagus and cardia, 50 unselected patients with tuberculosis were studied while they had pneumoperitoneum for therapeutic purposes.

The roentgenologic anatomy of the diaphragm, esophageal hiatus, lower thoracic esophagus and abdominal esophagus in the presence of pneumoperitoneum is described and the techniques used in this study are outlined.

The actual length of the abdominal esophagus was measured on the films in the upright and prone positions to evaluate the degree of elasticity of the abdominal segment. With increased intra-abdominal pressure (incident to pneumoperitoneum) and in the upright position, the abdominal segment of the esophagus appears to increase in length due to the elevation of the dome of the diaphragm and descent of the abdominal viscera. The right anterior oblique position is optimum for determining the true film length of the esophagus in these instances since the relief of direct pressure by intraperitoneal air in full inspiration is accomplished. Anatomic variations and the frequency of occurrence of these variations were noted; however, the average measurement was 2 cm.

It was found that the esophageal hiatus is nothing more than a hole in the diaphragm that accommodates the passage of the esophagus but serves no function in the action of the esophagus. Roentgenologically, the point where the esophagus seems to cross the right crus of the diaphragm is not necessarily the site of the esophageal hiatus, and its location must be surmised in most instances. Actually, it usually lies below the point where the esophagus crosses the right crus and it can be most accurately localized by filming the patient in a 30 degree rotation in full inspiration in the right anterior oblique position.

In only three of the patients were a sliding hiatal insufficiency, hiatus hernia and para-esophageal insufficiency, respectively, encountered. The incidence was lower than might have been suspected in the presence of pneumoperitoneum. Follow-up studies are being conducted to determine the incidence of these hiatal defects as a result of chronic pneumoperitoneum.

A summary is given outlining the anatomy and changes due to respiration in the different roentgen positions. The anatomical discussions are illustrated by roentgenographic reproductions and diagrams.—*Sue L. Nickey, M.D.*

Maisel, Bernard. Pneumoperitoneum in the preoperative preparation for total gastrectomy; an experimental study. *Surg., Gynec. & Obst.*, May, 1955, *100*, 595–598. (From: Department of Surgery, New York Hospital, Cornell University Medical College, New York, N. Y.)

The article is a further report of the use of pneumoperitoneum in dogs prior to total gastric resection as a means of facilitating exposure of the upper abdominal organs.

Fifty dogs of varying build were used, thirty receiving a pneumoperitoneum one to twelve days prior to exploratory laparotomy, total gastric resection and esophagojejunostomy; the remaining twenty served as controls.

The pneumoperitoneum produced three remarkable anatomic changes: (1) The diaphragm was elevated. (2) The abdominal wall was distended so that the peritoneal cavity was enlarged. (3) The subdiaphragmatic viscera, including stomach, pan-

creas, and lobes of the liver and spleen dropped below the costal margin. These changes were present in all the dogs that received a pneumoperitoneum, but were especially impressive in the dogs explored 12 days after the initial pneumoperitoneum.

These effects appreciably facilitated the performance of a total gastric resection and esophagojejunostomy since the duodenum, stomach, and spleen, and the lower end of the esophagus could easily be exposed through a right subcostal incision. They were most striking in the dogs of short "dumpy" build as the lower end of the esophagus could not be delivered into the wound in control dogs of similar build.—*John F. Weigen, M.D.*

KUMP, WARREN L., JORGENS, JOSEPH, and RIGLER, LEO G. Ectopic gastric mucosa in a congenital small bowel diverticulum; roentgen demonstration and report of a case. *Radiology*, July, 1955, *65*, 81–85. (From: Department of Radiology of the University of Minnesota Medical School and Veterans Administration Hospital, Minneapolis, Minn.)

Congenital small bowel diverticula occur in about 2 per cent of adults and are of two types: 1) Meckel's diverticulum which consists of a persisting portion of the yolk sac or vitelline duct; and (2) duplication of the bowel of disputed, and perhaps variable, embryologic origin, but unrelated to the vitelline duct. Meckel's diverticulum occurs on the antimesenteric side of the bowel, 20 to 100 cm. above the ileocecal valve in the adult, and its tip may be joined to the umbilicus by a fibrous cord. Duplication of the bowel is found most frequently in the ileum, almost always on the mesenteric side, and it may be tubular or cystic and may or may not communicate with the normal bowel lumen. Both may contain ectopic gastric or pancreatic tissue. Since roentgenologic distinction between the two types of congenital diverticula is difficult or impossible, it seems desirable for purposes of roentgen reporting to group both under the simple heading of congenital small bowel diverticula.

Both types of congenital small bowel diverticula have all four layers of the bowel wall and are thus distinguished from acquired diverticula, which contain no muscular coat. This distinction is sometimes possible preoperatively through the demonstration of peristalsis in the diverticulum at fluoroscopy, indicating the presence of a functional muscular wall.

A case of small bowel duplication with ectopic gastric mucosa in which a gastric rugal pattern was demonstrated roentgenographically is described, this being the first case reported in which a gastric rugal pattern was recognized preoperatively and verified as surgery.—*Harold C. Hamilton, M.D.*

SNAPE, W. J. (Camden, New Jersey.) Duodenal ulcer as an occasional etiologic factor in obstructive jaundice. *Ann. Int. Med.*, May, 1955, *42*, 1001–1010.

Duodenal ulcer has infrequently been reported associated with obstructive jaundice. It does occur, however, and is probably more frequent than has been assumed.

The author reports six cases collected in three years illustrating three suggested methods of production of jaundice: (1) The ulcer may impinge on the biliary papillae; (2) inflammation and edema of the pancreas caused by a posterior penetrating ulcer, may compress the common duct as it courses through the pancreas; (3) deeply penetrating or perforating ulcer may involve the gastrohepatic ligament and cause obstruction in the more proximal portion of the duct.

Clinically, most patients have a typical ulcer history associated with jaundice. The laboratory findings tend to indicate that this is an obstructive type of jaundice. The cases reported had an elevated alkaline phosphatase, depressed prothrombin time with a prompt response to vitamin K therapy. They also had absence of urinary urobilinogen.

Some of these cases had liver biopsy and three were explored surgically.

If an ulcer is demonstrated roentgenologically in the second portion of the duodenum or is penetrating deeply into the pancreas, and the patient is jaundiced, the patient should be started on appropriate ulcer therapy and the jaundice will probably clear.—*George L. Sackett, Jr., M.D.*

MAUTHE, HOWARD, and ZWICKY, GEORGE. Gastroduodenal intussusception. *Radiology*, July, 1955, *65*, 86–89. (From: St. Agnes Hospital, Fond du Lac, Wisc., and V.A. Hospital, Hines, Ill.)

Very few cases of gastroduodenal intussusception have been reported and in only two of the reported cases has the diagnosis been made prior to surgical exploration. In all of the reported cases there has been a neoplasm, usually on the posterior wall of the stomach, which is propelled by gastric peristalsis through the pylorus and into the duodenum, dragging a portion of the stomach wall behind it. Roentgen findings are a large, well circumscribed filling defect in the duodenum surrounded by streaks of contrast material trapped in the folds of the duodenal mucosa with concomitant shortening and distortion of the distal end of the stomach. The streaks of contrast material in the folds of the duodenal mucosa tend to arrange themselves in a circular or "bedspring" pattern almost identical with those seen about an ileocecal intussusception.

Two cases of gastroduodenal intussusception, one due to a large gastric lipoma and the other to a polypoid adenocarcinoma, which were correctly diagnosed preoperatively by roentgenologic examination are reported.—*Harold C. Hamilton, M.D.*

Cimmino, Christian V. Gastric adenomyosis vs. aberrant pancreas. *Radiology*, July, 1955, *65*, 73–77. (From: Mary Washington Hospital, Fredericksburg, Va.)

Nodules made up of varying proportions of undifferentiated and differentiated epithelial acinar structures within a smooth muscle matrix are occasionally found within the wall of the stomach and elsewhere in the alimentary tract. The extreme cases in which the epithelial components consist almost exclusively of undifferentiated acinar tissue have been called adenomyosis. Cases with differentiated tissue comprising pancreas alone have been designated aberrant pancreas. Those in which Brunner's glands are the sole component are known as heterotopic Brunner's glands.

The author presents a case in which the roentgenologic preoperative diagnosis was aberrant pancreas in the stomach, while the pathologic diagnosis was adenomyosis. On the basis of a study of this case, it is proposed that the term aberrant pancreas be abandoned roentgenologically in favor of adenomyosis until study of more cases establishes significant differences. The diagnosis of the specific differentiation should be left to the pathologist.

Gastric aberrant pancreatic tissue is visualized roentgenologically as a sharply-defined polypoid mass usually within 5 or 6 cm. of the pylorus, often with a small central depression that changes in diameter from time to time. The clinical picture is apparently similar in adenomyosis and pure aberrant pancreas, and the roentgenologic findings are probably identical.—*A. W. Sommer, M.D.*

Cronkhite, Leonard W., Jr., and Canada, Wilma Jeanne. Generalized gastrointestinal polyposis; an unusual syndrome of polyposis, pigmentation, alopecia and onychotrophia. *New England J. M.*, June 16, 1955, *252*, 1011–1015. (From: Departments of Medicine and Radiology, Massachusetts General Hospital, Boston, Mass.)

The authors report the cases of two female patients 42 and 75 years old respectively, with generalized polyposis of the gastrointestinal tract and ectodermal changes evidenced by alopecia, skin pigmentation and atrophy of the nails. In the first case the symptoms of nausea, vomiting and diarrhea appeared 8 months before death. The progress of the disease was rapid and the patient actually died of starvation. It is of interest that the skin pigmentation and alopecia appeared early while absorption was still normal. On the other hand, the second and older patient had gastrointestinal symptoms and skin changes for many years. She lived actively to the age of 75 when the disease took a more rapid course and death occurred within 18 months.

In both cases roentgen studies of the gastrointestinal tract revealed diffuse polyposis in the stomach, duodenum, small and large intestines, the changes being more pronounced and diffuse in the colon. Biopsy and autopsy studies in the first case demonstrated benign adenomatous polyps. The ectodermal changes reflected the deficiency state due to gastrointestinal disease. The eventual cause of death was starvation.

Review of the literature on the subject of polyposis revealed two distinct clinical entities: (1) polypoid adenomatosis of the colon which is a familial disease. The polyps are most evident in the colon and appear early in life, increasing in number through the second and third decades. (2) Peutz-Jeghers syndrome, also familial, occurs early in life. There are melanin spots at the mouth, lips and digits in addition to the intestinal polyps. These two groups account for only a small percentage of the total reported. The remaining cases ranged from a single asyptomatic polyp at any level of the gastrointestinal tract to multiple polyps with practically a total replacement of the mucosa. The question arises: Is it a matter of difference in severity of the same disease, or are they separate diseases?

On the basis of present knowledge the following rather superficial classification is made: (1) familial (polypoid adenomatosis of the colon and Peutz-Jeghers syndrome) and (2) non-familial (single adenomatous polyp, multiple adenomatous polyps and generalized gastrointestinal polyposis.)

The authors feel that the cases reported fall into the last of these classifications. Reproductions of seven roentgenograms accompany the article.—*William H. Shehadi, M.D.*

Poppel, Maxwell H., Adler, H., Jacobson, Harold G., Stein, J., and Lawrence, L. R. Mucous colon. *Radiology*, July, 1955, *65*, 50–56. (From: Departments of Radiology of New York University College of Medicine and Veterans Administration Hospital, New York, N. Y.)

The syndrome of mucous colon consists of diarrhea with mucus in the stool, frequently associated with abdominal pain, occasional vomiting, fullness, and belching. The physical findings may consist of tenderness in the region of the descending colon and a firm, palpable, tube-like descending colonic segment. The general condition is good.

The etiology of mucous colon is not known, but there is evidence that it is a manifestation of psychological conflicts with somatic complaints referable to the large bowel.

Roentgenologically, no abnormal structural changes are demonstrated. One may, however, find functional abnormalities evidenced by peculiar mucoid material in the colon, spasticity, and peristaltic effort. Spastic irregularity of size, shape, and balance in spacing of haustral markings has been

described. After evacuation of barium enema, the roentgenograms have showed the mucosa to be thickened as the result of "white edema." Frequently, motor dysfunction of the small intestine has been noted.

The authors have tabulated their observations in 17 cases. They state that the condition has no relation to ulcerative colitis.—*A. Ralph Watson, M.D.*

McLAREN, J. W., KING, J. B., and COPELAND, W. A. Preliminary observations on veripaque, a colonic actuator for use with barium enemata. *Brit. J. Radiol.*, June, 1955, *28*, 285–294. (Address: J. W. McLaren, Radiological Department, St. Thomas's Hospital, London, S.E.1, England.)

A new roentgenological adjuvant veripaque (diacetylbisoxyphenylisatin) and a technique for its use are described. The action of this drug on the colon is believed by the authors to be due in part to irritation. In this respect it is said to be superior to tannic acid.

Veripaque enables contraction and emptying of the colon to be observed by fluoroscopy and produces an excellent mucosal pattern.—*James J. McCort, M.D.*

COHEN, OSCAR H. Limy ductus choledochus. *Radiology*, July, 1955, *65*, 78–80. (Address: 115 Church St., Boonton, N. J.)

Limy bile in the ductus choledochus is rarely demonstrated roentgenographically, a survey of the literature failing to reveal any case in which this phenomenon was conclusively observed. The formation of limy bile in the gallbladder is basically part of stone formation with precipitation of calcium carbonate occurring in the presence of a blocked cystic duct associated with low-grade chronic inflammation of the wall.

A case is presented in which limy bile was demonstrated roentgenographically in the ductus choledochus due to the presence of a stone in the ampulla of Vater causing retention of the limy bile.—*Harold C. Hamilton, M.D.*

ROOT, JOSEPH C., and LEWIS, ROBERT F. A comparison of a new cholecystographic medium, Teridax, with Telepaque. *Radiology*, May, 1955, *64*, 714–717. (From: The Cleveland Clinic Foundation and The Frank E. Bunts Educational Institute, Cleveland, Ohio.)

The authors present the results of their experience with teridax, a new cholecystographic medium. The compound was administrated to 472 patients. A control series of 57 patients received telepaque, given in doses of 2.0 to 3.0 grams. The minimum dose of teridax administered to women was 4 tablets (3.0 gm.) Men received a minimum dose of 5 tablets (3.75 gm.). An additional tablet was given for each 25 pounds of body weight over 150 pounds.

Teridax yields visualization of the gallbladder comparable to that achieved with telepaque, but up to twice as much medium in relation to body weight is required as with telepaque. The authors believe that this increased dosage is the cause of the higher incidence of side effects in their teridax series. —*A. W. Sommer, M.D.*

GYNECOLOGY AND OBSTETRICS

McDONALD, EUGENE J. Evaluation of placentography in late bleeding of pregnancy. *Radiology*, June, 1955, *64*, 826–830. (Address: 1150 Connecticut Avenue, N. W., Washington 6, D. C.)

Painless bleeding in the last trimester of pregnancy always raises the possibility of the presence of placenta previa. At such times, several diagnostic procedures may come to mind, but one must not forget that soft tissue roentgenography is a simple, safe, and accurate procedure that requires no special preparation of the patient, no pelvic manipulation, and no injection of an opaque medium. Interpretation of the films requires only understanding, diligence, and observation of all the shadows which are present.

The author states that localization of the placenta should be first attempted on the lateral recumbent film. This examination is easily carried out, even in patients who are quite sick. It has been found that on this film, if the placenta lies above an imaginary equator transversely through the shadow of the gravid uterus, placenta previa can be excluded. The lower the center lies below the equator, the greater the likelihood of marginal or central implantation. Of aid in localization of the placenta are the digitations which can sometimes be seen. These placental impressions are apparently due to the proximity of fat-covered fetal parts which cast more radiolucent shadows.

Erect studies, in the anteroposterior and lateral projection, if obtainable are of great value in that the presenting part is observed in its lowest relationship with the inlet. In this instance, any lateral or unbalanced displacement not caused by full bladder or rectum is highly suggestive of low implantation. Of even greater importance is the fact that the placenta passes through the inlet in low implantation and must therefore necessarily increase the distance between the presenting part and the pelvic brim. It is stated by the author that in his opinion a head-pubis distance of 3 cm. or head-promontory displacement of 1.5 cm. or more is consistent with the diagnosis of low placental implantation.

Of further interest is the observation that with either high fundal or central placenta position, the internal shape of the uterine cavity is changed from the normal ellipse to a sphere. Since the fetus at-

tempts to accommodate to the most advantageous position, there is no more reason for it to be in a cephalocaudal diameter than in any other position. It has been observed, however, that it is extremely unusual to see a breech presentation associated with placenta previa, and transverse positions are frequently so associated.

The high accuracy of a negative diagnosis and the complete safety of the lateral and anteroposterior soft tissue technic roentgenogram make this procedure desirable in all cases in which placenta previa is suspected.—*A. Ralph Watson, M.D.*

Baker, Kenneth. Vaginal delivery after lower uterine cesarean section. *Surg., Gynec. & Obst.*, June, 1955, *100*, 690–696. (From: Department of Obstetrics and Gynaecology, University of Liverpool, Liverpool, England.)

Vaginal delivery following lower segment cesarean section is an accepted mode of delivery in the majority of the large maternity hospitals in this country. Although the mathematical chances of a lower segment scar undergoing disruption in labor have never been assessed, experience shows that the risk is small. To reduce this risk to a minimum, careful selection of cases, avoiding those with a weak scar, is an essential, and two methods are suggested. First, intrauterine palpation should be carried out immediately after vaginal delivery, the value of which has been stressed by many. Secondly, hysterography performed some three months after the original cesarean section is suggested as a further method of detection of a weak scar. While it is not so reliable as intrauterine palpation, it is the only method available on which an assessment can be made for the first labor following cesarean section.

The results of hysterography indicate that it is possible to show a gross deficiency in a uterine scar by means of a well taken lateral hysterogram and that the method, though not universally reliable, is of value as a guide to the mode of delivery in a subsequent confinement. To this end hysterography was performed on 36 women who had recently been delivered by cesarean section. Of these, 2 appeared to have faulty scars but none has so far been delivered, so the roentgenologic and clinical findings cannot yet be compared.—*Eugene J. McDonald, M.D.*

Dell, J. Maxey, Jr., (Gainesville, Fla.) Correlation of the type of labor with the roentgen findings. *South. M. J.*, June, 1955, *48*, 604–609.

The purpose of this article is to present the author's experience of 1,000 obstetrical cases using the Ball method of cephalopelvimetry. The radiologist should select the one he feels is reliable and then plot his results. If there is some error in his method which is consistent, he will have a good method in spite of this error. No one can say that a pregnant woman will deliver a baby without difficulty, but we should strive to make our method of prediction as accurate as possible. Perhaps one of the greatest needs is a more accurate measurement of the head. Certainly the larger the head for a given pelvis the more difficult the labor and delivery will be, everything else being equal.

The author plotted his cases in respect to the pelvic inlet on large graph paper, with the head circumference in centimeters along the abscissa and the diameter of the conjugata vera along the ordinate. A similar graph was prepared for the outlet. There is a tendency to consider the plane of the pelvis at the ischial spine level as the last bony obstruction and this is the level which he speaks of as the outlet. Below this point the resistance is essentially that of soft tissue and the factor of the pubic arch, both of which are best evaluated by the obstetrician.

These graphs are explained in detail as to the significance of all of these measurements and their bearing on prediction of type of labor to be expected.—*Eugene J. McDonald, M.D.*

Marshak, Richard H., and Eliasoph, Joan. The roentgen findings in adenomyosis. *Radiology*, June, 1955, *64*, 846–851. (From: Department of Radiology, The Mount Sinai Hospital, New York, N. Y.)

Adenomyosis is defined as the heterotopic occurrence of islands of endometrium within the myometrial layer of the uterine wall. The authors present the results of a study of 150 cases of proved adenomyosis in which the roentgen diagnosis was established by hysterography in 38 cases.

Roentgenographically the most striking feature of this condition is the demonstration (by water soluble medium) of short spicule-like structures extending perpendicularly from the borders of the uterine cavity. These spicule-like structures vary in length from 1 to 4 mm. and the projections sometimes terminate in small sacs.

The uterine cavity may be either somewhat enlarged, or of normal size. Considerable enlargement of the uterine cavity is usually associated with the presence of intramural or submucous fibroids.

Several conditions must be considered in the differential diagnosis. Among these are the following: 1) Endometrial hyperplasia. 2) Penetration of contrast medium into the uterine musculature or vascular channels. 3) Submucous fibroids.

When adenomyosis is associated with marked endometrial hyperplasia, there is indistinctness of the margins of the uterine cavity and multiple small, usually smooth, filling defects due to endometrial polyps can be visualized. On occasion the endometrial hyperplasia may be so prominent that incomplete filling of the lateral margins of the uterine cavity occurs, producing irregular streaks of radio-

paque material adjacent to the apparent borders of the uterine cavity. These streaks do not connect with the border of the uterine cavity, and the discrete tubular appearance noted in adenomyosis is absent.

Entry of the radiopaque material into the uterine musculature is usually associated with obstruction of both tubes and the most common finding noted is a small collection of contrast substance above the superior border of the uterine cavity. When vessels and sinuses are filled with opaque medium the vascular network is easily recognized. Thickened walls of the uterus in adenomyosis may produce smooth filling defects which are very difficult to differentiate from submucous fibroids unless the characteristic spicules are seen.—*A. Ralph Watson, M.D.*

Coe, Fred O. Diagnostic radiology in obstetrics and gynecology. *South. M. J.*, June, 1955, *48*, 609–612. (From: Radiological Clinic of Drs. Groover, Christie, and Merritt, Washington, D. C.)

The author summarizes diagnostic aids offered by roentgenology to obstetricians and gynecologists. For hysterosalpingography he states his preference for lipiodol-type of medium and discards rapidly absorbed media. His injections are done without manometric control. The placenta is localized by exclusion if the head lies firmly in the midline, in the erect frontal and lateral studies.

His calculations show a fetal radiation dosage of 2.5 to 3.0 roentgens during pelvimetry which would seem to be of little significance in relation to any possible fetal damage.

Under cephalopelvimetry the head measurements taken from the routine films are discussed. His experience with the Mengert classification and its percentage relation with skull indices is established. He feels that when the head index is 80 per cent or greater that dystocia or arrest can be anticipated.—*Eugene J. McDonald, M.D.*

Genitourinary System

Teplick, J. George, and Yarrow, M. William. Arterial infarction of the kidney. *Ann. Int. Med.*, May, 1955, *42*, 1041–1051. (From: Department of Radiology, Kensington Hospital, and Department of Medicine, Albert Einstein Medical Center, Northern Division, Philadelphia, Penna.)

Acute occlusion of a renal artery is an entity that may be diagnosed by roentgen findings. If one can demonstrate a normal sized, nonfunctioning kidney by intravenous pyelography, and a normal appearing kidney by retrograde pyelography, the authors consider that this is diagnostic of arterial occlusion. Abdominal aortography can be used to demonstrate nonfilling of the affected vessel.

Clinically the patient, usually one with cardiac disease, has sudden, severe abdominal and flank pain for two to four days. He has albuminuria and approximately half of the cases exhibit hematuria.

Since the occlusion is not due to a septic embolus, a sterile autonephrectomy results with gradual shrinkage and atrophy of the kidney. Surgery is not indicated.

In contradistinction, occlusion of the renal vein is usually seen associated with a septic process such as thrombophlebitis and produces acute pain, fever and sepsis. The kidney becomes swollen and tender. On intravenous pyelography the kidney is nonfunctioning and enlarged and on retrograde pyelography it shows a narrowed or acutely occluded pelvis. Because of the associated infection, nephrectomy is indicated.

The authors report two cases of arterial occlusion which illustrate the above points.—*George L. Sackett, Jr., M.D.*

Lowman, Robert M., Shapiro, Harrison, Lin, Albert, Davis, Leonard, Korn, Francis E., and Newman, Harry R. Preliminary clinical evaluation of hypaque in excretory urography. *Surg., Gynec. & Obst.*, July, 1955, *101*, 1–8. (From: Department of Radiology, The Memorial Unit Grace-New Haven Community Hospital, Yale Medical Center, Yale University School of Medicine, New Haven, Conn.)

The authors present, as apreliminary report, the result of their studies on 300 patients following the use of hypaque (Winthrop 8308–3, 50 per cent aqueous solution) for intravenous urography together with a comparison with other contrast media employed for the same purpose.

The object of the study was: (1) to determine the efficiency of hypaque as a medium for intravenous urography, and the extent and seriousness of the reactions associated with its use, (2) to correlate the results of the preliminary testing procedures with subsequent reactions, (3) to determine the relative effectiveness of hypaque in visualizing the urinary tract.

Each patient was questioned about a history of allergy or untoward reactions to previous media used for a similar purpose. The examination was rarely undertaken when blood chemistry studies and urine specific gravity did not warrant the procedure. One or more of the known preliminary tests were done on each patient, using the ocular, oral, intradermal or intravenous methods.

The authors share with other workers the feeling that too much emphasis is laid on the value of preliminary testing. It is felt, however, that its use reflects a recognition of the serious nature of the examination and represents an attempt to meet the medico-legal considerations of this problem. The

tests are considered neither reliable nor infallible.

Animal studies revealed that the lethal dose for hypaque was 11,300 mg. per kg., and for urokon was 5,560 mg. per kg. Thus, toxicity of hypaque is one-half that of urokon.

In the 300 cases examined, nausea, vomiting, flushing of the face and dizziness were noted in only 8 patients. No reactions were observed when hypaque was used in 9 patients who had experienced reactions following the use of other media. There was no venal spasm. In one patient the contrast medium escaped into the antecubital fossa. Within 24 hours there was no residual reaction.

The authors conclude that with the use of hypaque there is significant reduction in the incidence of reactions, even when the entire ampule of 30 cc. is injected in 2 or 3 minutes. The urographic density is greater than with all other media. In 50 per cent solution its density is similar to that produced by other media at 70 per cent concentration (urokon and others). No true allergic reactions are noted.

Thus far, it has been gratifying to use a contrast medium producing a high quality excretory urogram with absence of major side reactions.

Three tables and reproductions of 3 roentgenograms accompany this excellent report.—*William H. Shehadi, M.D.*

Evans, John A., Monteith, James C., and Dubilier, William, Jr. Nephrotomography. *Radiology*, May, 1955, *64*, 655–663. (From: New York Hospital-Cornell Medical Center, New York, N. Y.)

Nephrotomography is a combination of rapid intravenous nephrography and laminagraphy. The procedure has been found to be of considerable value in the differentiation of renal cysts from neoplasms. The technic has been described in a previous report by the authors, but briefly consists of the rapid intravenous injection of 50 cc. of urokon to which 5 cc. of decholin has been added in order to determine the circulation time. Quickly following this the nephrotomograms are taken.

One hundred cases have been examined by this method, 3 of which were normal controls. The remaining 97 were examined because of suspicious findings on intravenous or retrograde pyelography. Cysts were demonstrated in 42 cases and carcinomas in 11, while most of the remaining ones were normal. Extrarenal pathology was demonstrated in 15 cases.

Cysts appear as well circumscribed areas of radiolucency surrrounded by opaque renal parenchyma. Superficially located cysts however, are less easily identified since they are not surrounded by renal parenchyma. Neoplasms appear as opaque areas of equal or greater density than the surrounding parenchyma. In the arterial phase of the examination an abnormal vascular bed may be identified in contrast to the avascular cyst.—*Donald N. Dysart, M.D.*

Creevy, C. D., and Price, W. E. Differentiation of renal cysts from neoplasms by abdominal aortography: Pitfalls. *Radiology*, June, 1955, *64*, 831–839. (From: Division of Urology in Department of Surgery, Medical School of the University of Minnesota, Minneapolis, Minn.)

Although as a general rule renal cysts and neoplasms can be rather easily differentiated, there are times when usual methods of examination fail to reveal a clearcut diagnosis. The question can be settled by surgical exploration, but it is preferable, if possible, to know the diagnosis beforehand for a number of reasons.

Of the various supplementary methods, two stand out as being of most value. In a symptomless but palpable lesion suggestive of a cyst, the diagnosis may often be clinched by diagnostic aspiration and injection of a contrast agent. If the resulting shadow in the roentgenogram is sharply marginated, of uniform density, and devoid of filling defects, the diagnosis of cyst is safe and exploration unnecessary in view of the rarity of neoplasms arising within cysts. Abdominal aortography is potentially most useful in the study of lesions of doubtful character which are visible on roentgenogram but not palpable. The value of this method in urological diagnosis depends on the delineation of the nature and extent of the blood supply of the kidney and of a suspected mass. Its use may aid in determining whether a kidney damaged by disease is worth saving, in demonstrating the size, configuration and vascularity of a kidney poorly outlined by other methods, and in supplying details not otherwise available concerning congenital anomalies. It brings out fetal lobulation in a striking manner, thus explaining some minor but perplexing pyelographic deformities.

The worth of abdominal aortography in differentiating renal cysts and neoplasms depends upon the marked difference in their vascular patterns. The solid neoplasms of the renal parenchyma are characterized by irregularly arranged collections of vascular sinuses, usually described as puddling. Unfortunately, eptheliomas of the renal pelvis and the rare intracystic papillary cystadenocarcinomas are not sufficiently vascular to show as such in angiograms.

Solitary cysts appear as circular or oval defects in the renal circulation which, when typical, are unmistakable. There may be a thin rim of vessels at the periphery of the cyst, but the individual vessel is normal in appearance, lacking the irregular dots and dashes of the parenchymal neoplasm.

Unfortunately, in the authors' experience, not all renal masses show the typical vascular abnormalities; a parenchymal neoplasm may resemble a cyst, and cysts may present atypical patterns which will confuse the observer. Moreover, large neoplasms or their metastases may so compress the renal artery

as to prevent delineation of their blood supply. These shortcomings of renal angiography are demonstrated by 7 case reports.

With increasing experience, it has become evident that renal angiography may be just as inconclusive as pyelography in distinguishing cysts from parenchymal neoplasms and is inferior to pyelography in the diagnosis of epithelioma of the renal pelvis. Neither procedure is adequate for recognition of the rare papillary intracystic cystadeno-carcinoma, which with either method produces deformities that are indistinguishable from those of simple cysts.

The desirability of going as far as possible with the preoperative differential diagnosis is emphaszied, but there remains a small group of lesions in which surgical exploration is necessary to make sure that a neoplasm is not being mistaken for a cyst.—*A. Ralph Watson, M.D.*

HARTL, H. Die Ergebnisse der Urethrozystographie bei der Frau. (Findings of urethrocystography in women.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, May, 1955, *82*, 680–686. (From: Universitäts-Frauenklinik, Göttingen, Germany.)

According to the author urethrocystograms can give information on two points: 1. the condition of the pelvic floor on straining and 2. the function of the sphincters.

The first can be demonstrated on cystograms obtained in the erect position both at ease and on straining. The two exposures are made in the posterio-anterior projection and can be made on the same film, superimposed on each other. In normal subjects, the floor of the bladder runs horizontally at the level of the upper border of the symphysis or at its middle and on straining descends by 1–1.5 cm. In incontinence, the floor of the bladder shows greater mobility on straining. A funnel-shaped bulging of the bladder floor on straining and in severe cases also at ease is particularly typical for incontinence.

To demonstrate the sphincter tonus, an apparatus consisting of an inflatable balloon communicating with a graded manometer tube filled with radiopaque material was used. Films were obtained both at ease and while straining. In normal subjects, the balloon remained in the bladder at pressures up to 30 cm. water. In incontinence, bulging of the bladder floor due to insufficiency of the internal sphincter was noted at pressures from 10 to 30 cm. water. The function of the voluntary sphincter could also be evaluated.

Thirteen roentgenograms, several drawings and a photograph of the apparatus used are reproduced. Numerous references are given at the end of the article.—*Karol E. Matzinger, M.D.*

ANDERSEN, POUL E. Pneumoretroperitoneum in suprarenal disease. *Acta radiol.*, April, 1955, *43*, 289–296. (From: Roentgen Department, University Hospital, Copenhagen, Denmark.)

The author reviews the historical development of pneumoretroperitoneum and presents his experience with 48 cases, 12 of them proven by operation, to illustrate the diagnostic value of air studies in suprarenal disease.

The technique described is to place the patient in a knee-elbow or left lateral decubitus position, ½–1 hour following sedation. The skin just anterior to the tip of the coccyx is prepared and injected with the needle directed by a finger in the rectum to the retrorectal areolar tissue of the anococcygeal raphe. After precautionary aspiration, 1,500 cc. of oxygen are injected at the rate of 150–200 cc. per minute. A 2–2 liter O_2–H_2O bottle system is used for hydrostatic pressure and safety buffer.

After withdrawal of the needle, the patient is placed in the erect, right lateral, and left decubitus for several minutes. Four standard roentgenograms —prone, supine, left and right oblique—are then taken.

No untoward complications have occurred. Mediastinal, cervical emphysema and pneumoperitoneum have been seen in several cases.

Fifty-four pneumoretroperitoneum studies have been carried out in 48 cases suspected of having either Cushing's syndrome, pheochromocytoma, hypertension, adrenal cortical hyperplasia, adiposity or amenorrhea. Of 12 proven cases, 9 were diagnosed and localized correctly by the radiologist. Of 25 cases with endocrine evidence of hyperfunction, only 9 showed roentgen evidence of enlarged adrenal glands. This seemed to confirm previous authors' evidence of dissociation between the roentgenologic and biologic signs in adrenal cortical hyperfunction.

The normal variations encountered in roentgenographic evaluation were a) sharply demarcated, triangular shadows; the right smaller than the left, b) vaguely demarcated, homogeneous, triangular shadows with inferior border confluent with the kidney, and c) vaguely demarcated, non-homogeneous vertically streaked or granular shadows, the so-called lipoparenchymatous type.—*Merrill I. Feldman, M.D.*

HAMM, FRANK C., and SCORDAMAGLIA, LOUIS J. A diagnostic aid for visualization of the left suprarenal space. *J. Urol.*, May, 1955, *73*, 885–887. (From: Department of Surgery, State University of New York, College of Medicine at New York City and University Division, Kings County Hospital, Brooklyn, N. Y.)

The authors point out the confusing shadows that occur in the left suprarenal area, one of which is the

contracted fundus of the stomach. Their technique for differentiating this soft tissue shadow from that of an adrenal tumor is as follows: The patient is prepared for pyelography according to the customary procedure, and, in addition, he receives nothing by mouth for a period of five hours prior to the test. A mixture of sodium bicarbonate and tartaric acid in water is given to the patient at the time of pyelography. This will distend the fundus of the stomach and eliminate its soft tissue density.

The differential diagnosis of the soft tissue shadows in this area must also include the abnormally placed spleen, or accessory spleens, cysts and malignant tumors of the upper pole of the kidney and other retroperitoneal tumors extrinsic to the adrenal body.

Gas distention of the stomach is offered as diagnostic procedure to eliminate one confusing shadow.

Six illustrations demonstrate the condition described.—*George W. Chamberlin, M.D.*

Nervous System

Wolkin, Julius, Sachs, Maurice D., and Hoke, George H. Comparative studies of discography and myelography. *Radiology*, May, 1955, *64*, 704–713. (From: Radiological Service and Neurosurgical Section, Veterans Administration Hospital, and Western Reserve University School of Medicine, Cleveland, Ohio.)

This article concerns a series of 27 patients in whom the value of diskography and/or myelography was studied. Twenty-six underwent lumbar interlaminar explorations at which herniated disks were found, while the last patient underwent no surgery.

In 18 patients, both procedures were performed preoperatively, while in 9 only diskography was done. In 11 of the 18 patients subjected to diskography and myelography, both procedures were accurate. Considered alone, myelography was completely accurate in 9 of 18 cases, partly accurate in 3, falsely negative in 4, falsely positive in 1, and unsatisfactory in 1. Diskography alone was completely accurate in 18 of 27 cases, partly accurate in 7, falsely positive in 1, and unsatisfactory in 1. There were no false negative diskograms.

The technic of performing diskography is outlined and the advantages and disadvantages of this procedure are discussed. It is not recommended if there is a question of a tumor or other pathological change involving the nervous system, and it should not be substituted for myelography when the latter is indicated.

In this small series, the accuracy of diskography was better than that of myelography. A normal diskogram offers very strong evidence against the diagnosis of a herniated lumbar disk.—*Donald N. Dysart, M.D.*

Rayle, Albert A., Jr., Gay, Brit. B., Jr., and Meadors, Jason L. The myelogram in avulsion of the brachial plexus. *Radiology*, July, 1955, *65*, 65–72. (From: Departments of Radiology, Emory University School of Medicine and Grady Memorial Hospital, Atlanta, Ga.)

Although avulsion of the brachial plexus is a well known entity, little attention has been paid to its roentgenologic features.

The authors review the literature and present nine cases in which the myelographic findings are considered pathognomonic for avulsion or high rupture of the cervical nerve roots. The principal feature of such a myelogram is extravasation of the contrast medium into a diverticulum-like collection beyond the level of the root pouch as a result of rupture of arachnoidal and dural investments of the nerve roots. Avulsion may occur without myelographic changes. Intradural exploration of the brachial plexus may therefore be necessary at times for final evaluation of the extent of damage.

Myelography may be of considerable value in handling brachial plexus injuries. If one sees changes indicating root avulsion or high rupture corresponding to the clinical level of involvement, satisfactory repair is considered impossible and no significant regeneration can be expected. In such cases early orthopedic reconstructive surgery is indicated to give as useful an arm as possible.—*A. W. Sommer, M.D*

Pahl, R. Doppelter Nervenkanal der Klavikula als diagnostische Fehlerquelle (Zugleich ein Beitrag über das Foramen nervi supraclavicularis). (A double nerve canal of the clavicle as a diagnostic source of error; also a contribution on the foramen nervi supraclavicularis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 487–491. (From: Röntgen- und Geschwulstabteilung des Rudolf Virchow Krankenhauses, Berlin, Germany.)

The author reports a very rare case of a double nerve canal in the left clavicle. At first, it was regarded as an osteolytic metastatic lesion inasmuch as the patient was 56 years of age and was suffering from metastatic bone disease. Only after exposure of a spot film in the second oblique position was a correct diagnosis made which was confirmed at autopsy.

The author was not able to find any mention in the literature of this variant of two nerve canals. In 1827, one case was reported by Bock in which he described anatomically one nerve canal. Later in 1849, Gruber reported one case. In 1928, Santos found one nerve canal in 6–7 per cent of 450 skeletons, and the last known anatomical report was made by Ahlborg in 1931, who found 6 per cent one nerve canals in 100 skeletons. These nerve canals may be

mistaken for nutrient canals. Differential diagnostic is the fact that the nerve canal runs perpendicular to the bone and has an exit opening while the nutrient canal runs obliquely in the spongiosa and shows no exit opening.—*S. Silvera, M.D.*

ROSENDAL, TH. The development of the calcanean foot deformity after poliomyelitis. *Acta orthop. Scandinav.*, 1955, *24*, 216–249. (From: Danish National Association for Infantile Paralysis, Research and Treatment Institute and Sundby Hospital X-Ray Department, Copenhagen, Denmark.)

The author studied the roentgenograms of 167 feet of patients with paralysis of the triceps and in most cases of one or more muscles of the lower leg and foot, following poliomyelitis. He showed that the deformity in the paralytic calcanean foot is caused by a change in the shape and/or position of the calcaneus.

There has been considerable difference of opinion among various authors as to whether change in shape or position of the calcaneus was the main cause in the production of the paralytic calcanean foot. The time of onset of the disease and the localization, duration and degree of paralysis are all factors which determine whether change in shape or position, of the calcaneus, separately or combined, eventually will produce the deformity. No change in the shape of the calcaneus was found except where the onset of the disease came before the tenth year. The slighter degree of modification of shape can only be discovered by roentgen examination.

Change in the shape of the calcaneus will begin to appear from six to twelve months after paralysis has begun in the form of atrophy of the calcaneal tubercle. This atrophy will be more pronounced the earlier in childhood the disease occurs, the longer the paralysis lasts and the more paralytic is the triceps. Later, plantar prominence of the posterior process of the calcaneus occurs.

With paralysis of all of the muscles of the leg combined with the varus position of the foot due to paralysis of the peroneals a condition known clinically as a "calcaneo-varus foot" may result. In these cases there is no elevation of the anterior extremity of the calcaneus as this portion of the calcaneus is under the head of the talus due to the varus deformity.

Change in the position of the calcaneus is shown by elevation of its anterior extremity and may begin within the first six months after the onset of the disease. An important factor is the valgus position of the hind-foot, which will permit the anterior extremity of the calcaneus to glide up on the lateral aspect of the head of the talus.

The association of pronounced positional changes usually combined with a change in shape of the calcaneus results in two types of deformities. The "paralytic, neutral calcanean foot" develops when the triceps is paralytic and the other muscles of the leg and planta are intact and the lateral balance of the foot is good. The "paralytic calcaneo-valgus foot," which occurred more frequently in the author's series, results from elevation of the anterior extremity of the calcaneus on the talus.

Treatment which is important in the prevention of marked deformities, consists of physical therapy and application of braces and, in indicated cases, of surgery.—*J. N. Ané, M.D.*

SKELETAL SYSTEM

WOOLLEY, PAUL V., JR., and EVANS, WILLIAM A. Significance of skeletal lesions in infants resembling those of traumatic origin. *J.A.M.A.*, June 18, 1955, *158*, 539–543. (Address: Dr. Woolley, 5224 St. Antoine St., Detroit, Mich.)

The authors review briefly the literature of osseous lesions resembling trauma that are seen in infants in whom no history of injury can be elicited, and outline two fundamental queries emerging from these publications: (1) Are these infants predisposed to skeletal changes resulting from the usual minor injuries incurred in infants by inherent bone fragilities, or (2) are these the roentgen manifestations of normal bones to abnormal forces of trauma? To answer these questions, the physical and domestic environments of children manifesting these bone changes were scrutinized through various sources and means of investigation.

Four broad conclusions are drawn: (1) History of trauma may or may not be elicited. There are no roentgenological criteria for classifying cases on the basis of whether a history of trauma is or is not elicited. (2) The general environmental factors surrounding infants with fractures range from "unavoidable" episodes in stable households to a surprisingly large segment characterized by the presence of aggressive, immature, or emotionally ill adults. (3) There is little evidence supporting "unusual fragility" of bone as an entity during infancy, or of any association between subdural hematoma and increased skeletal fragility. There should be no confusion between recognized clinical states leading to hypothetic increased tendency to fracture and the multiple skeletal defects that appear grossly to be due to unrecognized trauma. (4) A study of twelve infants with multiple areas of bone damage and yet no history of trauma showed invariably that they came from unstable households with neurotic or frankly psychotic behavior on the part of at least one adult. Healing was uncomplicated and no new lesions developed upon removal of these infants from their adverse environment.

The over-all conclusion is that these are normal children whose skeletal lesions have resulted from "undesirable vectors of force."—*Paul W. Mathews, Jr., M.D.*

Cohen, Jonathan, and Craig, John M. Multiple lymphangiectases of bone. *J. Bone & Joint Surg.*, June, 1955, *37-A*, 585–596. (From: Department of Orthopaedic Surgery and Division of Laboratories and Research, The Children's Medical Center, Boston, Mass.)

A case of a disseminated skeletal disease producing multicentric destructive lesions of bone is presented. The principal pathological feature was the presence of dilated intraosseous lymphatic vessels producing extensive cystic lesions of the bones. Pathologic classification of the process could not be done even with multiple biopsies, extensive clinical observation, and autopsy findings. The entity was termed multiple lymphangiectases of bone.

Roentgenographically, the lesions appeared as multiple small cystic areas in the medullary portion of the affected bone, a "soap-bubble" appearance, which gradually enlarged and coalesced to produce a picture of pressure erosion from within the ultimately destroyed normal bony architecture. Long bones and flat bones were equally involved with multiple pathological fractures and collapse being seen as the disease progressed.

A search of the literature revealed three similar cases which were considered as neoplasms. Autopsy material was not available in these cases.—*Robert B. Connor, M.D.*

Gershon-Cohen, J., and McClendon, J. F. Roentgenography of osteoporosis due to lathyrism in the rat; effect of rock phosphate in the diet. *Radiology*, May, 1955, *64*, 727–730. (From: Department of Radiology and Biochemistry, Albert Einstein Medical Center, Northern Division, Philadelphia, Penna.)

Osteoporosis may develop in animals who ingest an excess of seeds of the flowering sweet pea. An organic toxic substance has been shown to be present in these seeds, and apparently it can cause a marked effect on the nervous as well as the osseous system.

The authors produced the above changes in rats and demonstrated the profound osteoporosis by roentgenograms. The disease process is called lathyrism, for flowering sweat pea seed is named Lathyrus odoratus. The addition of brown rock phosphate to the diet of these rats did not influence the osteoporosis.—*Clyde A. Stevenson, M.D.*

Davis, Lawrence A., and Hatt, William S. Congenital abnormalities of the feet. *Radiology*, June, 1955, *64*, 818–825. (From: Departments of Radiology and Surgery (orthopedic Section), University of Louisville School of Medicine, and Kosair Crippled Children Hospital, Louisville, Ky.)

The authors describe their technic for obtaining roentgenograms in standard views of the infant foot and present criteria for the analysis of the normal and the abnormal infant foot. Since at birth the talus and calcaneus are the only tarsal bones which are ossified, the anatomical analysis consists essentially in a description of the relationship of these two bones to each other and to the metatarsals.

Talipes equinovarus, "rocker deformity," flat foot, metatarsus varus and pes cavus are described. Roentgenographic reproductions and diagrams are presented to illustrate each of these types.—*Arno W. Sommer, M.D.*

Nesbitt, James, III, and Roth, Robert E. Solitary lytic bone lesion in an adult with chronic myelogenous leukemia. *Radiology*, May, 1955, *64*, 724–726. (From: Veterans Administration Hospital, Nashville, Tenn.)

Solitary destructive bone lesions from chronic myelogenous leukemia are rare, with only one case reported in the recent literature.

The case of a 42 year old white male with such a lesion, proven by needle biopsy and at necropsy, is presented. The patient had been treated for chronic myelogenous leukemia with radioactive gold a year before, and now had been having pain in the left knee for two months. The knee was swollen, tender, and erythematous on the anterolateral aspect, and he had temperature of 101.4° F.

Roentgenograms of the left knee showed an osteolytic area in the anterolateral aspect of the tibia just below the metaphysis, with complete erosion of the cortex, but little extension of the tumor into the adjacent tissues. A bone survey disclosed no other areas of bone involvement.

Palliative roentgen therapy (2,000 r tumor dose delivered in 17 days) produced no improvement, and the patient died. Postmortem examination confirmed the diagnosis.—*C. L. Stevenson, M.D.*

Russell, Delbert A., and Albrecht, Leroy. A new technic for radiology of the bony thorax and sternum. *Radiology*, May, 1955, *64*, 721–723. (From: Department of Radiology, Elyria Memorial Hospital, Elyria, Ohio.)

Use of no-screen film in cardboard holders and a Potter-Bucky diaphragm will produce roentgenograms of the bony thorax of much better detail than the conventional screen technic. This method is of particular value for demonstrating fractured ribs, although with extremely heavy individuals it is difficult to obtain good detail of both the upper and lower ribs on one film.

The technical factors employed by the authors are 200 ma., 75 kv., and 35 inches Bucky distance for a chest measuring 22 cm. With a rotating anode tube,

200 to 400 ma. can be used with a short exposure time to keep motion at a minimum.—*C. L. Stevenson M.D.*

Sulamaa, M., and Wallgren, G. R. Congenital high scapula (Sprengel's deformity). *Acta orthop. Sandinav.*, 1955, *24*, 195–206. (From: Department of Pediatric Surgery, Lastenklinikka, Helsinki, Finland.)

The authors present 4 cases of Sprengel's deformity between the ages of from 2 to 7 years. Associated spinal deformities were present in all cases and costal deformities were noted in 2 of the patients. One meningocele and 1 uranostaphyloschisis were found in the series. The operative indications consisted of cosmetic asymmetry, limited abduction and pain.

The authors describe their operative technic which is based on the Putti-Schrock method. The involved scapula was found attached to the spine by fibrous adhesions. In one case, an omovertebral bone was noted.

The cosmetic result was good in 3 cases and satisfactory in one. The postoperative course was uneventful in all cases. The authors recommend operation at the age of from 1 to 2 years.—*J. N. Ané, M.D.*

Lipscomb, Paul R., and Burleson, R. Joe. Vascular and neural complications in supracondylar fractures of the humerus in children. *J. Bone & Joint Surg.*, June, 1955, *37-A*, 487–492. (From: Section of Orthopaedic Surgery, Mayo Clinic and Mayo Foundation, Rochester, Minn.)

Vascular and neural complications associated with supracondylar fractures of the humerus in children are presented.

All cases of such injury seen at the Mayo Clinic from 1943 through 1952 in the age group of 14 years or younger were reviewed, but only the extension type of fracture is included in the series since it was found that only in this group did the complications occur. One hundred eight cases of this type were seen and of these, 24 (22 per cent) had vascular, or neural complications. There were 7 vascular injuries, 13 neural injuries (median nerve), and 4 patients had both neural and vascular complications.

Prompt recognition followed by necessary surgical treatment is imperative to prevent permanent disability of the affected extremity.—*Robert B. Connor, M.D.*

Devlin, James A., Bowman, Harold E., and Mitchell, C. Leslie. Non-osteogenic fibroma of bone; a review of the literature with the addition of six cases. *J. Bone & Joint Surg.*, June, 1955, *37*-A, 472–486. (From: Division of Orthopaedic Surgery and Department of Pathology, Henry Ford Hospital, Detroit, Mich.)

The authors present six cases of non-osteogenic fibroma of bone which satisfy the clinical, roentgenographic, and pathologic criteria originally described by Jaffe and Lichtenstein (*Am. J. Pathol*, 1942, 18, 205–221). This lesion has been previously interpreted as: "giant-cell variant of bone cyst or osteitis fibrosa," "healing variant of giant-cell tumor," "xanthic variant of giant-cell tumor," "solitary xanthoma or xanthogranuloma of bone," and "fibrous osteomyelitis."

The patients, 5 males and 1 female were between 6 and 14 years of age. The long tubular bones of the lower extremity were affected in all cases. Pain and swelling with tenderness over the tumor area were the predominant localizing complaints. Three of the cases had a history of trauma associated with discovery of the lesion, 2 of these had pathologic fractures. The other 3 cases gave no history of trauma but one had traumatic periostitis at the lesion associated with a fracture.

Roentgenologically, all 6 cases demonstrated location of a cystic tumor in the ends of the shalft of long bones close to the epiphyseal cartilage. Other similar characteristics were eccentric location, ovoid shape, longitudinal orientation, loculation of varying extent, and a well defined medullary border. All measured less than 4 cm. in length. Four cases showed cortical thinning.

Pathologic examination of surgical specimens from all 6 cases demonstrated gross reddish-brown to tan granular material. Microscopically, spindle-shaped connective tissue cells with tendency to whorl formation were seen. Foreign body giant cells were present in varying concentration depending upon the area examined. Foam cells were present in 2 of the cases.

Contrary to many bone tumors, the microscopic pattern in non-osteogenic fibroma is the determining factor in confirming the clinical and roentgenographic diagnosis.

Other lesions to be considered in differential diagnosis are osteogenic sarcoma, slow growing fibrosarcoma, osteitis fibrosa, single bone cyst, giant-cell tumor, and fibrous dysplasia. The authors emphasize that the lesion may be easily distinguished by careful evaluation of the clinical and roentgenographic findings together with the gross and microscopic findings.

All the lesions were treated by curettage, 4 also receiving cancellous bone packing. Two of the cases showed no evidence of tumor after limited follow up but the remaining 4 showed either evidence of persistence or recurrence. All had symptomatic relief.—*Merrill I. Feldman, M.D.*

Bean, William Bennett. Dyschondroplasia and hemangiomata (Maffucci's syndrome). *A.M.A. Arch. Int. Med.*, June, 1955, *95*,

767–778. (From: Department of Medicine and University Hospitals of the College of Medicine, State University of Iowa, Iowa City, Iowa.)

Maffucci's syndrome is an inborn dysplastic mesodermal anomaly in which dyschondroplasia and vascular hemangioma (angioma, phlebectasia, and hamartoma) occur together.

The author describes in detail and illustrates by photographs and roentgenographic reproductions three cases that were seen at the University Hospitals of the State University of Iowa during the past two years. Seven additional cases of Maffucci's syndrome reported since 1942 are reviewed. This brings the total reported cases to 30.

The disease should be suspected early in life when unusual hemangiomata of the skin do not regress or disappear. In childhood the dyschondroplastic disorder may cause various deformities and pathologic fractures. Enchondromata in phalanges and metacarpals are found in addition to dyschondroplasia.

The several kinds of tumors to which victims of Maffucci's syndrome have succumbed—chondrosarcoma (four), angiosarcoma (one), malignant lymphangioma (one), glioma (one), and ovarian teratoma (one)—demonstrate the high incidence of malignant neoplasm.

It is hoped that a better understanding of this disorder may be found since it produces such devastating deformities and is attended by a high incidence of malignant neoplastic change.—*B. J. Parnell, M.D.*

Jacobson, Harold G., Herbert, Earle A., and Poppel, Maxwell H. Arthrogryposis multiplex congenita. *Radiology*, July, 1955, *65*, 8–18. (From: Departments of Radiology, Hospital for Special Surgery and New York University College of Medicine, New York, N. Y.)

Arthrogryposis is a rare congenital disease characterized by flexion and/or extension contractures of a few or many joints of the extremities, associated with marked muscle bundle atrophy and osteoporosis, most marked in the affected limbs. Clubfoot and congenital hip dislocations are frequently present, and numerous other musculoskeletal deformities are often found. Both sexes are affected, but it is more common in males.

Its etiology is unknown, and the numerous theories that have been proposed are presented. However, the bone deformities are probably secondary to the muscular inbalance resulting from congenital deficiencies of muscles. Most authors doubt that any hereditary factors are involved. The pathological findings have been reported in only a few cases, and these are controversial.

Clinically, one or all four extremities may be involved, and rarely the head and trunk. The affected limbs are small in circumference, making the joints appear unusually large. Commonly, both flexion and extension contractures are present, but in some cases only one type occurs. Usually some slight active and passive motion of the joints is possible, and only rarely is there complete ankylosis. Other findings are: muscular weakness and hypotonia, thin or nonpalpable muscles, absence of tendon reflexes, and thickened, flabby, wrinkled skin and subcutaneous tissue. Electrical reactions are weak or absent, but no reaction of degeneration is present. Many musculoskeletal anomalies may be present.

Thirteen cases have been studied by the authors, and the important clinical and roentgen findings are tabulated. In this series, 7 were males and 6 females, all were white except for 1 negro, 5 were of Jewish background (the significance of this racial distribution could not be biometrically analyzed), and all had the disease at birth. There may be some relationship between arthrogryposis and delivery, since 6 of the 13 patients had an abnormal delivery.

Roentgenographically, the muscle bundle atrophy is best shown in the lower extremities, where the thin muscle fibers can be clearly seen, resembling the configuration of tendons and ligaments. The osteoporosis is most evident in the extremities, with moderate porosis of the spine, and little involvement of the skull. The bony texture resembles that seen in osteogenesis imperfecta, but the cortex is thicker. Numerous associated deformities and musculoskeletal anomalies may be seen.

The roentgenographic findings correlated with the clinical picture are diagnostic, and this entity should not be confused with amyotonia congenita, osteogenesis imperfecta, poliomyelitis, and infantile muscular atrophy.—*C. L. Stevenson, M.D.*

Brenizer, Addison G., Jr. (Charlotte, N. C.) Primary hyperparathyroidism. *Ann. Surg.*, May, 1955, *141*, 722–736.

Primary hyperparathyroidism is caused by excessive production of parathyroid hormone and is characterized by the laboratory findings of hypercalcemia, hypophosphatemia and hypercalcinuria. It is usually diagnosed because of its complications which may involve the skeleton or the urinary tract, separately or in combination. The excess of hormone is produced most commonly by one of two benign parathyroid adenomas, sometimes by diffuse parathyroid hypertrophy and very rarely by a parathyroid carcinoma.

In recent years cases with extensive skeletal lesions are not common, because bone disease is prevented or ameliorated by moderate use of milk or dairy products in the diet. Urinary tract stones or nephrocalcinosis, present in 75 per cent of the reported cases are the more common complications of the disease. The group at the Massachusetts General Hospital believes that 5 per cent of all stones en-

countered are due to parathyroid disease.

Classically, hyperparathyroidism produces a generalized skeletal decalcification, and there may be scattered localized tumors or cystic lesions. The skull shows a granular decalcification with ragged areas of bone resorption and the lamina dura about the teeth may be lost. Where involved, the phalanges show a characteristic subperiosteal resorption of bone which produces a lacelike pattern seen in no other condition. The roentgenologist must differentiate this disease from osteoporosis, osteomalacia, fibrous dysplasia and osteitis deformans. Serum calcium and phosphorus are normal except in periods following fracture and immobilization, when hypercalcemia may occur. Secondary hyperparathyroidism resulting from phosphate retention or tubular dysfunction may produce bone lesions indistinguishable roentgenologically or pathologically from the primary type. In such cases the serum calcium is normal or low.

Metastatic lesions in bone, multiple myeloma, and sarcoidosis may produce hypercalcemia and bone changes, and must be considered in the differential diagnosis.

In practice, the commonest and most difficult diagnostic problem is the case with calcium deposits in the urinary tract, borderline values for serum calcium and phosphorus and no recognizable skeletal disease. Forty per cent of the Mayo Clinic cases are reported as falling into this group.

The author discusses in some detail the anatomic considerations as related to surgical treatment of parathyroid adenoma. Postoperative care and the dangers of severe tetany of recalcification in the individual with extensive bone disease is pointed out. Four of the author's own cases are reported, all caused by single mixed-cell type benign adenomas found in the neck. Three of the 4 patients had bone lesions. There were no mortalities and 1 patient has been followed fourteen years.—*Arthur B. Smith, M.D.*

GOLDMAN, LEON. Unusual manifestations of hyperparathyroidism. *Surg., Gynec. & Obst.*, June, 1955, *100*, 675–689. (From: Department of Surgery, University of California School of Medicine, San Francisco, Calif.)

Hyperparathyroidism has many unusual manifestations that obviate early diagnosis. Early diagnosis is desirable in order to forestall formation of renal calculi and subsequent renal damage, fractures and skeletal deformities. Prevention of renal lesions is important as uremia and hypertension may develop.

Hyperparathyroidism is diagnosed from the laboratory findings of hypercalcemia, hypophosphatemia and hypercalcinuria.

Seven cases are presented in which parathyroid adenomas were found at operation:

Case 1 showed a typical primary hyperparathyroidism with generalized osteitis fibrosa and nephrolithiasis. The patient had renal colics 9 years previously and also had multiple fractures, weakness, polydypsia and polyuria for 7 years. Roentgenograms of the skeleton demonstrated a generalized demineralization, with mutiple cystic areas. The tips of the distal phalanges were resorbed. Dental roentgenograms made elsewhere 2 years previously showed absorption of the lamina dura.

Case 2 had a nephrolithiasis with no osseous involvement. A right nephrectomy was done 3 years previously for renal calculi and pyelonephritis. Three months prior to being seen, she had a left ureteral calculus which prompted the hyperparathyroid studies. Nephrolithiasis without osseous involvement makes up 60 per cent of all cases of primary hyperparathyroidism. Those patients with a high calcium intake do not develop the demineralization. Two to five per cent of all cases of nephrolithiasis with calcium phosphate and calcium oxalate stones are secondary to hyperparathyroidism.

Case 3 was that of a 17 year old girl who had been seen elsewhere with a fracture through a cystic area in the left humerus. Radiation therapy was given because the lesion was thought to be a giant cell tumor. She had clinical, laboratory and roentgenological findings indicative of hyperparathyroidism.

Case 4 was that of a brother of Case 3 who had a cyst in the symphysis of the mandible. Biopsy showed a giant cell reaction and a giant cell tumor was suspected. Laboratory and roentgenological findings demonstrated hyperparathyroidism. Roentgenograms of the esophagus showed a deviation to the right just below the larynx, indicating a left sided tumor. Ten years later there was a recurrence of symptoms, including a cyst in the right ring finger, and another parathyroid adenoma was found. His renal function became gradually worse and he died 4 years after the second parathyroidectomy of uremia, hypertension and myocardial failure. The renal insufficiency progressed after the parathyroidectomy. The tubules were chiefly involved.

Case 5 showed renal insufficiency following the removal of a parathyroid adenoma. Renal colics occurred 3 years before he fractured his left hip. Later he developed a spontaneous paraplegia without skeletal deformity. Roentgenograms revealed typical changes of hyperparathyroidism. The renal function was diminished somewhat at that time. Eleven years later the renal function was worse and the demineralization of the bones was thought to be due to renal osteodystrophy.

Case 6 showed a typical Paget's disease which was associated with hyperparathyroidism. Two operations were needed to find the parathyroid adenoma.

Case 7 was that of a 51 year old male who was thought elsewhere to have a metastatic carcinoma of the prostate. A later evaluation showed roentgeno-

logical and laboratory changes of hyperparathyroidism. An epulis was excised from the lower mandible and giant cell reaction was found. Two parathyroid adenomas were found at the first operation and later an additional one was discovered.

It is concluded that nonrecognition or lack of consideration of hyperparathyroidism was the most common cause for delay in treatment of these cases. The unusual manifestations of this disease emphasize the need for complete clinical, chemical and roentgenological studies in all allied types of bone disease and in all patients with renal calculi. Bone lesions heal following the removal of the tumor, but the renal lesions are often progressive and renal insufficiency and hypertension may develop. This makes early diagnosis imperative.—*Charles W. Cooley, M.D.*

Blood and Lymph System

Lemcke, W. Erfahrungen mit Urografin "Schering" in der zerebralen Angiographie. (Experiences with Urografin Schering in the cerebral angiography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 504–505. (From: Röntgenabteilung der II. Med. Klinik und Poliklinik der Med. Akademie, Düsseldorf, Germany.)

Since the exhaustive investigations of Tore Broman, Bengt Forssman and Olle Olsson about "The tolerance of the cerebral blood vessels to contrast media of the Diodrast group" it is known that injuries to the vascular structures in the nature of disturbance of the permeability of the blood vessel wall depend on the concentration of the contrast medium, on the interval between the injections and on the number of injections administered.

Winzer, Langecker and Junkmann found definite relationship between the general toxicity and the restraint of vesicular respiration. They are of the opinion that the reason for the low restraint of vesicular breathing of the triiodides is the larger molecular weight.

The author used urografin at first for urography and found it to be more tolerable and to give better picture contrast than the diiodides, especially in patients with low specific gravity of the urine.

He then used it for cerebral angiography in 20 cases by injecting it through the carotid artery. The patients rank from 22 to 60 years of age. In four cases a brain tumor or metastasis was found. In three cases the angiography did not confirm the clinical suspicion of vascular damage. He injected twice 8–9 cc. of the medium at 5–10 minute intervals. The 76 per cent original solution was diluted with distilled water or saline in proportions of 5:5, 6:4, 7:3, 8:2. Once the original solution was injected undiluted. No ill effect was encountered in any case. No pain was observed during the injection. With a mixture of a concentration higher than 6:4 (45 per cent urografin) the patient complained of a slight warm feeling during and for a short time after the injection.—*S. Silvera, M.D.*

Albrecht, K. Ein Beitrag zur Herabsetzung der Gefahren bei der zerebralen Arteriografie durch Trapanal-Kurznarkose (Gleichzeitig über einen Fall von tödlich verlaufender Thrombose der Karotis nach Arteriografie). (A contribution to reduce the danger in cerebral arteriography using trapanal short-anesthesia; also a report of a fatal case due to thrombosis of the carotid following arteriography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 495–500. (From: Chirurgische Universitätsklinik, und Neurochirurgische Abteilung. Erlangen, Germany.)

The causes for fatal outcome following peripheral and cerebral arteriography are divided in two groups; those due to the method of injection and those due to the medium used. Large hematomas in the neck with breathing difficulties are more common with cutting into the carotid then with injection through the skin. In the former, there is also the danger of infection. The author reports one case in which the cause of death was a large thrombus in the injected carotid. In analyzing the reasons for the formation of a thrombus, he comes to the conclusion that it is dangerous to hold the needle in the blood vessel for a length of time until satisfactory films are secured. He recommends to rather puncture the carotid a second time if necessary.

In discussing the causes attributable to the contrast medium, the author enumerates the following possibilities: irritation of the vessel wall, disturbance of the cerebral vessel permeability with ensuing cerebral edema, change in the internal pressure of the blood vessel which partly is due to arteriospasm and sensitivity to the drug. To avoid these risks, the author uses a short-lasting anesthetic, trapanal, while doing the cerebral arteriography and found it to be satisfactory from many aspects. In 150 cases, no ill effect was encountered due to the anesthetic. Sensitivity reactions are less to fear under anesthesia. Also, there occurs less arteriospasm as proven by lack of widening of the pupil on the side injected.—*S. Silvera, M.D.*

Decker, K. Die A. ophthalmica im Karotisangiogramm. (The ophthalmic artery in carotid angiograms.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, May, 1955, *82*, 667–673. (From: Röntgenabteilung der Universitäts-Nervenklinik, München, Germany.)

With the use of a manual cassette changer, the filling of the branches of the ophthalmic artery was

inconstant. After introducing Schoenander's seriograph, filling was regularly observed and angiography was used in investigation of orbital and ocular lesions, the results of which are described.

Filling of the arteries of the eyeball occurs usually 2–3 seconds after injection and lasts 2 to 5 seconds. The author uses Schoenander's seriograph and takes two films during each of the first 2 seconds after injection and one film during each of the following 4–5 seconds. Exposures are made in the lateral projection, the time of exposure being 0.14 sec. and the kilovoltage 4 kv. less than for a carotid angiogram. A single postero-anterior film is taken, with the central ray perpendicular and the neck in slight dorsiflexion.

Positive angiographic findings were obtained in occlusion of the arteria centralis retinae. In circumscribed retinal vascular occlusions and in periphlebitis retinae, the angiographic findings were normal. In orbital tumors originating from the ethmoid cells, displacement of the ophthalmic artery medially was noted. Angiomata of the orbit were clearly visualized. The degree of protrusion of the eyeball in exophthalmos could be measured.

In 6742 carotid angiograms, performed in the author's laboratory, only two ocular complications occurred due to micro-emboli of peripheral retinal vessels with a defect in the visual field of less than one quadrant.

The article contains 8 reproductions of angiograms and several references from both American and Continental literature.—*Karol E. Matzinger, M.D.*

MONEY, R. A., and VANDERFIELD, G. K. Angiography in the management of intra- and supra-sellar tumours. *J. Neurosurg.*, May, 1955, *12*, 203–215. (From: Department of Neurosurgery, Royal Prince Alfred Hospital, Sydney, Australia.)

This article deals with the usefulness of carotid angiography in the preoperative evaluation of intra- and suprasellar tumors, including those arising from the olfactory groove and the third ventricle. A table is given which lists the clinical, roentgenographic, and operative findings in 21 illustrative cases in which this procedure was employed. Cerebral angiography was used with excellent utility in corroborating the diagnosis and in providing information as to the situation and size of the lesion, thus guiding the surgeon towards the safest and easiest approach.

Bilateral carotid angiograms were obtained, and, in the event that satisfactory filling of the anterior cerebral arteries did not occur, pneumoencephalography or ventriculography was performed (the choice of the latter two depended upon the absence or presence of hydrocephalus).

Correlation of the angiographic interpretations and surgical findings permitted an evaluation of the diagnostic features of the angiograms and these are illustrated and described individually. Displacement of major vessels was variable depending upon the site and size of the tumor mass. Intrasellar tumors produced only an elongation and unbuckling of the carotid siphon and displaced the more distal portions of the internal carotid artery laterally and anteriorly. The anterior cerebral artery at its division from the internal carotid artery formed an obtuse angle. Suprasellar lesions displaced the anterior cerebral artery upward and posteriorly, reversing the normal anterior convexity, but tumors in this situation had little, if any, effect on the position of the internal carotid artery. Tumors of the third ventricle which have not eroded or enlarged the sella had little effect upon the angiogram except those incident to hydrocephalus (which is usually seen as a stretching of the anterior cerebral artery) whereas those which have produced secondary sellar changes may also demonstrate irregular deformities of the carotid siphon.

Tumors arising primarily in the pituitary gland did not exhibit the tumor staining of an intratumor circulation; but tumors of the olfactory groove or the third ventricle often showed the presence of this pathological circulation.

Other uses of angiocardiography are to verify or exclude the presence of a tumor, and in some cases indicate the type of abnormality that exists. For example, aneurysms in the region of the circle of Willis or internal carotid artery may clinically simulate pituitary tumors and even produce erosion of the sella turcica. The diagnosis of course is obvious with the employment of arteriography. Not the least important information gained from angiography is the indication of the tumor size and extent. Primary pituitary tumors may extend anteriorly as extrasellar lesions and the delineation of this roentgenographically is important to the surgeon and his approach. Angiography is also used to determine the cause of postoperative complications. In one case it was shown that the postoperative symptoms were the result of thrombosis of an anterior cerebral artery.—*John W. Wilson, M.D.*

LIN, PAUL M., MOKROHISKY, JOHN F., STAUFFER, HERBERT M., and SCOTT, MICHAEL. The importance of the deep cerebral veins in cerebral angiography; with special emphasis on the orientation of the foramen of Monro through the visualization of the "venous angle" of the brain, *J. Neurosurg.*, May, 1955, *12*, 256–277. (From: Departments of Neurosurgery and Radiology, Temple University Hospital and School of Medicine, Philadelphia, Pa.)

The authors present a review of the anatomy of the deep cerebral veins. Their importance in the diagnosis of space-occupying lesions is re-emphasized. Of the deep cerebral veins, the internal cerebral vein is especially vulnerable to changes in posi-

tion and is of value in the diagnosis of deep-seated lesions, including those of the third ventricle and basal ganglia.

The change in the position of the "venous angle" is described for tumors in various locations. This is the angle formed by the striothalamic vein and the internal cerebral vein and localizes the posterior border of the foramen of Monro.

The authors present orientation measurements in the lateral projection using the anterior convexity of the "venous angle." Charts are made of the orientation of the venous angle using the same principle employed in the construction of the Vastine-Kinney chart for pineal body localization. The study includes 200 normal and abnormal cases on which cerebral arteriograms were performed. The frequency with which the visualization of the deep cerebral veins occurred was about 75 per cent. The normal limits of the venous angle are plotted as well as displacement in proved space-taking lesions in various locations.

Several excellent roentgenographic reproductions are included.—*T. F. Meaney, M.D.*

Vaughan, Robert H., Deterling, Ralph A., and Smith, Frederick M. Successful excision of an aortic aneurysm explored as a paraspinal tumor. *New England J. Med.*, July 7, 1955, *253*, 15–17. (From: Departments of Surgery and Orthopedic Surgery, Columbia University College of Physicians and Surgeons, and Surgical Service, Presbyterian Hospital, New York, N. Y.)

This is a case report of a 49-year-old negro chauffeur with a syphilitic aneurysm of the aorta at the level of T-11 and T-12. Roentgenographically the saccular aneurysm appeared as a mass protruding on both sides of the spine and laminagraphy showed a destructive process involving the bodies of the two adjacent vertebrae, especially on the left. There was a narrowing of the intervertebral disk space. The roentgenographic impression was that this represented chronic infection, probably tuberculosis, and the second most likely possibility listed was a chondroma. The laboratory findings were within normal limits except for a positive Mazzini test. Needle biopsy was inconclusive. The patient was explored surgically and a saccular aneurysm was found. It was successfully excised and the aorta closed.

An aneurysm is uncommon in the suprarenal portion of the abdominal aorta, but, when found there, generally it is of syphilitic origin. The bone destruction that is seen with syphilitic aortic aneurysms is rarely observed with abdominal aneurysms which are usually arteriosclerotic. Differentiation of luetic and arteriosclerotic aneurysms is of practical value since the former are more localized with normal aorta existing just proximal and distal to the lesion. This permits more complete resection of the diseased segment and firmer continuity may be established by approximating and closing two normal aortic ends.

It is concluded that an angiocardiographic study in the lateral position probably would have disclosed the vascular origin of the mass and more satisfactory preoperative preparations could have been made.—*B. J. Parnell, M.D.*

Barnes, Benjamin A., Shaw, Robert S., Leaf, Alexander, and Linton, Robert R. Oliguria following diagnostic translumbar aortography; report of a case. *New England J. Med.*, June 30, 1955, *252*, 1113–1116. (Address: Dr. Barnes, Instructor in Surgery, Harvard Medical School, Massachusetts General Hospital, Boston, Mass.)

The authors present a case of prolonged oliguria after diagnostic translumbar aortography. A 57-year-old man was admitted with a diagnosis of thrombosis of the abdominal aorta. Four months previously, he had had an aortogram in another hospital. There was no history of renal disease, allergy or iodism. Translumbar aortography was performed using 70 per cent iodopyracet (diodrast). The initial injection of 20 cc. of the opaque medium resulted in extravasation. After the position of the needle had been corrected, 50 cc. of medium was injected. There was no unusual reaction except for moderate transient nausea and retching. The aortogram showed excellent filling of the renal, superior and inferior mesenteric arteries. The aorta was obliterated below the interspace between L 3-4, and the opaque medium reached the iliac arteries by a rich anastomosis. On the 4th day after this procedure, bilateral submaxillary adenitis developed. It was noted that progressive oliguria had developed since the aortography. Acute renal failure ensued. On the 8th day the patient presented a manifestation of cardiac failure in addition to painful and swollen joints and mental depression. The patient was treated with sharply restricted fluid intakes, use of a cation-exchange resin to promote potassium excretion, and a pure carbohydrate diet. He gradually improved, and within five weeks was essentially well.

The authors postulate that the complete block of the abdominal aorta caused both kidneys to be perfused with a high concentration of contrast medium. This may have produced renal damage, or possibly the previous exposure to an iodinated compound resulted in an allergic reaction manifested by oliguria. The authors emphasize that the information to be gained from translumbar aortography must fully justify the inherent risk of the procedure.—*B. Aramsri, M.D.*

Riches, E. W. The present status of renal angiography. *Brit. J. Surg.*, March, 1955, *42*, 462–470. (Address: Middlesex Hospital, London, England.)

The author describes the two routes of approach to aortography, the lumbar and the femoral. He favors the lumbar approach "as the easier, quicker, and less prone to failure or complication." He advises the femoral approach in cases of aortic aneurysm and in extreme obesity. No appreciable extravasation of blood following aortic puncture has been experienced, no ruptured aortas, and as all patients are tested for sensitivity to diodone and have previously had excretion pyelograms, no serious sensitivity reactions have been encountered. One patient experienced a renal shut-down with anuria for six days following a double injection of diodone, but recovered under intragastric drip of glucose and arachis oil.

In the author's technique general anesthesia is used and four films at each injection are exposed. Injection and film changing is done manually. Films are processed, with the needle left in place, and a second injection made if necessary. Retrograde pyelography and perirenal insufflation have at times been combined with aortography with advantage.

Accurate preoperative diagnosis between renal new growths and renal cysts is made possible by renal angiography. New growths may show displacement of vessels near the tumor, but the tumor itself presents a mottled appearance due to pooling of contrast medium into the vascular spaces. A solitary cyst on the other hand, is itself avascular and presents a translucent area in the nephrogram, with vessels curving around the area. Differentiation here is of great significance, as a renal cyst may not require surgery, or the cyst itself may just need excising, without sacrificing the kidney.

The author feels that renal angiography may detect an early cortical neoplasm before it has reached a calix.

Renal pelvic tumors are best diagnosed by the filling defect of pyelography. If the tumors are large enough to displace the kidney laterally the renal artery will be elongated as in hydronephrosis. If a pelvic tumor invades the parenchyma it is usually avascular and shows small vessels and an absent nephrogram in the invaded area.

Polycystic disease shows a poor blood supply with small vessels spread around the cysts, and a patchy cotton-wool appearance of the nephrogram. Methods other than renal angiography, however, are more diagnostic of polycystic disease and safer where renal function is impaired.

In hydronephrosis the author uses renal angiography both to determine the presence or absence of accessory vessels and to determine renal function. He believes the aortogram to be more reliable than the intravenous pyelogram as a test of renal function. The degree of reduction of the size of the main renal artery, the number of peripheral branches, and the density of the nephrogram all give an indication of the function of the kidney. Plastic operation on hydronephrotic kidneys requires adequate blood supply to the part, whether or not aberrant lower polar vessels are the cause of the obstruction; and hydronephrosis can usually be determined by angiography. When vessels to a hydronephrotic kidney are small and the other kidney is normal, the author does a nephrectomy, rather than attempting a repair. This procedure has given good results in hypertension, and the author speculates as to whether renal angiography, by showing the relative size of renal arteries, will give the best indication for nephrectomy in unilateral renal hypertension.

Renal angiography is of great value in any condition where partial nephrectomy is contemplated, e.g. hydrocalicosis with or without stone. Congenital anomalies, e.g., absence of one kidney, ectopic kidneys, double kidneys, etc., are well demonstrated. The author has been unable to show changes in the nephrogram in tuberculosis, as has been reported by others. Aortography demonstrates well the contracted small kidney , and the author has had some gratifying results in hypertension by removing a small nonfunctioning hydronephrotic kidney. Retroperitoneal tumors can be distinguished from renal swelling by renal angiography, but the author believes these can better be delineated by presacral insufflation. He has had no opportunity to study kidney infarction, and has as yet received no help from renal angiography in cases of unexplained hematuria.

The author believes the procedure to be safe, reasonably easy, and adaptable to any good general hospital. He states that it is essential in the investigation of any space-occupying lesion of the kidney, of hydronephrosis, of congenital anomalies, and of any condition for which partial nephrectomy is contemplated. It is also desirable in suspected renal hypertension. It is contraindicated in iodine sensitivity and uremia. It complements, but does not replace, standard urological investigations.—*L. E. Sargent, M.D.*

JOHNSON, GEORGE F. Venography and surgery of the postphlebitic syndrome. *Surg., Gynec. & Obst.*, July, 1955, *101*, 9–14. (From: Departments of Radiology and Surgery, St. Luke's Hospital, Cleveland, Ohio.)

Venography is an important contribution to the surgical management of peripheral venous thrombosis and postphlebitic ulceration. The author presents typical examples of a series of 100 cases to illustrate the roentgenographic findings in various stages of venous thrombosis—without ulceration, transitional, and with ulceration.

Following deep venous thrombosis, there is reversal of peripheral blood flow toward the superficial veins. The communicating veins become incompetent followed shortly by superficial system incompetency. With recanalization of the deep venous system, the third major venous pathway of the lower extremity is also incompetent. The clinical manifestations of

this chain of events are edema, stasis dermatitis, and ulceration. Fifty per cent of patients with venous thrombosis develop ulceration if followed at least 10 years.

The technique used is to begin an intravenous drip with a No. 20 needle in a small vein on the dorsum of the foot, on the side of ulceration perferably. After applying an ankle tourniquet, 30 cc. of 35 per cent diodrast is injected into the intravenous tubing occluded proximally. Films are then exposed as follows:

a) anteroposterior, lower leg in 20° internal rotation;
b) lateral, with tourniquet removed;
c) repeat anteroposterior, film 2–3 inches cephalad;
d) anteroposterior, thigh and lower pelvis following an additional 10 cc. of diodrast.

The veins are then flushed with normal saline and modifications such as repeat injection, leg dependency, multiple or no tourniquet, exercise response, and retrograde injection are used depending on individual venographic detail.

In the "without ulceration" stage, typical roentgenographic findings are obstruction, dilatation of the collateral veins, contour irregularities in the vein walls and filling defects within the veins. Anatomic identification of collateral and perforating systems is important to surgical planning. In the pelvis, four major types of collateral veins are present, the pudendal, gluteal, midsacral and inferior epigastric veins. Identification of the mid Hunter canal perforator, the low and midtibial perforation of the geniculate plexus is important in planning adequate surgical relief.

In the "transitional stage," there is further dilatation of collateral veins with occasional recanalization in the deep system. This is evidenced by a wavy, contoured appearance.

The final or "ulceration stage" exhibits incompetency of all 3 venous systems with recanalization of the deep system in every case.—*Merrill I. Feldman, M.D.*

Moore, Thomas C. Functional venography with injection into superficial veins. *Surg., Gynec. & Obst.*, June, 1955, *100*, 721–729. (From: Surgical Service, Ball Memorial Hospital, Muncie, Indiana, and Department of Surgery, Indiana University Medical Center, Indianapolis, Ind.)

Functional venography offers promise of advancing knowledge of normal venous physiology and venous disorders of the lower extremities.

Method: A roentgenographic table was used with the foot being tilted downward 60 degrees. A 7×17 inch cassette was placed under the thigh and another under the lower leg. Thirty cc. of urokon was injected slowly. Roentgenograms were made directly after injection and repeated in one minute after the patient had exercised by contracting the leg muscles and raising on his toes. The best results were obtained when the injection was made in the region of the knee or calf. The injections were made either percutaneously into a visible or palpable vein or through a polyethylene tube that was placed into the vein through a cut down. A cut down was made into the saphenous vein in the region of the medial malleolus when the other veins were not prominent. The polyethylene tube was then inserted up to the mid calf level. If venous obstruction was suspected, the main saphenous channels were not used to avoid possible occlusion.

Four cases are presented: Case 1 showed lesser saphenous incompetency and a normal deep venous system; Case 2 showed a postthrombotic state and established the secondary nature of the varices. The deep venous system was patent and functioning although it was recanalized; Case 3 showed that the popliteal-femoral vein was not outlined and that the urokon passed proximally in the saphenous system toward the heart; and Case 4 showed that the deep venous system did not visualize.

The following observations were made:

1) When the injection was made into the superficial venous system of normal patients, or those with varicosities, or with a patent but re-canalized deep trunk, the radiopaque medium filled the popliteal-femoral vein, passing proximally against gravity in the deep venous system, rather than through the superficial venous system. The medium cleared from the deep venous system with exercise.

2) The superficial venous system in dependency served principally as a collecting system for the superficial areas for the central segmental passage of venous blood directly into the deep venous system, rather than as a major channel for venous return.

3) The failure of the deep venous system to opacify and the proximal passage of the medium against gravity into the superficial venous system were regarded as presumptive evidence of deep venous obstruction.

Superficial injections were found to be less painful, and more reliable than the popliteal-femoral injections and also showed the function of the superficial venous system. Functional venography is an adjuvant and does not replace a detailed history and thorough examination for diagnosis of vascular disturbances.—*Charles W. Cooley, M.D.*

Felder, Davitt A. Analysis of a method of phlebography of the lower extremity in the semi-erect position. *Radiology*, June, 1955, *64*, 852–857. (From: Departments of Surgery and Radiology, University of Minnesota Medical School, Minneapolis 14, Minn.)

The author presents an analysis of a method of phlebography of the lower extremity using stereoroentgenograms with the subject in the semi-erect

position at 65 degrees from the horizontal. Fifty-three studies in 28 patients were made by this method, and the results are compared with those obtained with other methods. Three different clinical groups of extremities were studied: A. those with no history or evidence of venous disease; B. those with superficial varices without a history of previous deep-vein thrombosis; C. those with a history of deep-vein thrombosis as well as evidence of venous disease.

The method of administration is described in detail. With a tourniquet applied snugly about the ankle, injection of diodrast 35 per cent is made into veins on the dorsum of the foot. Serial stereoroentgenograms are made subsequent to the injection.

The studies indicate that phlebography in the upright position, by the "isoflow" technic, has a practical application. Such studies can be expected to visualize the major deep veins of the leg, with the exception of the anterior tibial and sural veins, in at least 90 per cent of the examinations. The popliteal vein and the lower femoral vein should be demonstrated approximately 100 per cent of the time in normals and in patients with chronic deep-vein disability. The deep femoral vein of the thigh is not satisfactorily visualized by this method.—*Arno W. Sommer, M.D.*

DOEHNER, G. A., RUZICKA, F. F., HOFFMAN, G., and ROUSSELOT, L. M. The portal venous system: Its roentgen anatomy. *Radiology*, May, 1955, *64*, 675–689. (From: Departments of Radiology, Pathology, and Surgery, St. Vincent's Hospital and New York University College of Medicine, New York, N. Y.)

The roentgen anatomy of the portal venous system was studied by injection of ghe portal system in cadavers and by portography in the living subject in the course of surgery for conditions other than those involving this system. The portal venous system as demonstrated by postmortem portograms may be divided into three anatomical classifications based on the angle formed by the portal and splenic veins (portosplenic angle): 1) The "T" type with a portosplenic angle exceeding 140 degrees; 2) the "Y" type with a portosplenic angle under 80 degrees; and 3) the "tripod" type with a portosplenic angle between 90 and 140 degrees. Of the 50 cases in this series, 40 were of the "tripod" type; 5 of the "T" type, and 5 of the "Y" type. Some correlation was found between the type of portal system and the habitus, with the "T" types tending to occur in patients of hypersthenic habitus and the "Y" types in patients of hyposthenic habitus.

Observations were made on variations in the major tributaries, and measurements of diameters and lengths of the more important vessels were secured. Measurements made in the postmortem portograms were slightly greater than in those made at operation. Factors believed to be of importance in explaining these differences are dilatation and elongation of veins in postmortem material and contraction of veins caused by the injected contrast medium in the living.—*Harold C. Hamilton, M.D.*

CATALANO, D., GIARDIELLO, A., and RUGGIERO, A. Hepatography after percutaneous lienoportal venography. *Acta radiol.*, April, 1955, *43*, 285–288. (From: Surgical Clinic and The Roentgen Department, University of Naples, Naples, Italy.)

Conventional roentgenography, pneumoperitoneum and extraperitoneal insufflation of air with and without laminagraphy have until recently been the only means of roentgen examination of the liver, other than the portion forming the biliary tract. Because of this it has not been possible to study intrinsic pathology.

The authors have obtained visualization of the portal vein by introduction of contrast medium by the transparietal intrasplenic route. This technique shows splenic, pancreatic, and liver pathology. The contrast medium injected into the splenic parenchyma passes through the splenic and portal veins into the liver. The first films show intrahepatic branches—later ones show diffuse opacification of the liver. The procedure is easy to perform and relatively safe.

Liver opacification cannot be achieved in cases of splenic or portal venous obstruction. In these cases the method is only good for demonstration of the cause and site of obstruction. However, without obstruction the method will outline intrahepatic disease, particularly space-occupying lesions, in a great many instances.—*E. C. Davis, M.D.*

REYNOLDS, TELFER, B., MIKKELSEN, WILLIAM, and REDEKER, ALLAN G. Splenic hemorrhage following percutaneous splenoportography. *J.A.M.A.*, June 11, 1955, *158*, 478. (Address: Dr. Reynolds, 1200 N. State Street, Los Angeles, Calif.)

A brief review of the technique of percutaneous injection of radiopaque material into the spleen resulting in a portal venogram and an attached bibliography are given.

It is pointed out that the reports on this method indicate that the complication of bleeding occurs infrequently and is not serious as a rule; however, the authors have been reluctant to employ this method, regardless of the previous reports, unless valuable information appears to be available by its use. Therefore, they have used percutaneous splenoportography in only three instances, each of which was followed by the complication of splenic hemorrhage. In the first patient, the splenic injection was performed immediately prior to a scheduled laparotomy. At the time of the laparotomy a subcapsular hema-

toma measuring 10 by 6 cm. was found. The splenoportogram on the second patient was obtained on the operating table while the abdomen was open and brisk splenic hemorrhage occurred which was controlled by pressure. In both of the above cases, splenectomy was performed as a therapeutic procedure for portal hypertension for, in each case, the extrahepatic obstruction was in the splenic vein. The third patient that underwent splenoportography is presented as a case report. Following the percutaneous injection of the spleen with 30 cc. of sodium acetrizoate 70 per cent (Urokon®) there followed signs of subdiaphragmatic irritation which was later superseded by evidence of fluid in the flanks. Operation was performed and approximately 1,500 cc. of blood was found in the peritoneal cavity and there was a large hematoma distending the capsule of the spleen. Blood was oozing slowly from a small 3 to 4 mm. needle rent in the lower pole. This third case is presented as an illustration of a serious complication of intrasplenic injection necessitating splenectomy for the control of the hemorrhage.

The authors conclude that the facility for splenectomy must be available before percutaneous splenoportography is employed.—*John W. Wilson, M.D.*

Tornvall, Gunnar, and Nordenström, Björn. Roentgenodensometric recording of hepatic and portal circulation. *Acta radiol.*, April, 1955, *43*, 276–284. (From: Roentgen Department, Sabbatsberg Sjukhus, Stockholm, Sweden.)

The authors describe an experimental method for recording the hepatic circulation in dogs. Sodium acetrizoate (70 per cent) was injected into the thoracic aorta of the dog in small amounts. A roentgen source was placed under the animal, and the reduced intensity of radiation which occurred when the medium passed through the liver, was recorded electrokymographically. A curve with two peaks was thus obtained, the first peak showing the response to the circulation in the hepatic artery, the second and more sustained peak being caused by the circulation in the portal circuit. Electrocardiograms were obtained concomitantly, a reference to which made it possible to measure the circulation time in the hepatic and portal circulations.

Respiratory distortions of the densograms were avoided by administering celocurine to the dogs which stopped their breathing during the procedure. Intratracheal oxygen was administered during the period of respiratory arrest.—*Denis V. Campbell, M.D.*

Giuseffi, Jerome, and Largen, Thomas. A method for determining the patency of portacaval and splenorenal shunts. *A.M.A. Arch. Surg.*, May, 1955, *70*, 707–714. (From: Department of Surgery, University of Cincinnati, College of Medicine, and Daniel Drake Memorial Hospital, Cincinnati, Ohio.)

A new experimental method of "trap" venography is described.

A catheter was improvised consisting of a three lumen polyethylene tube. Two lumens connect to two inflatable balloons situated 2 inches apart and the third lumen is used for the injection and is perforated over the interval between the balloons. The catheter is passed up the inferior vena cava, and with the aid of silver clips, is positioned fluoroscopically so that the proximal or superior balloon is above and the inferior balloon below the level of the anastomosis. When the proper location has been attained, both balloons are inflated with iodopyracet solution until the desired portion of the vena cava is "trapped."

This method has been employed in the laboratory in a series of thirty dogs. It has been used to visualize portacaval and splenorenal shunts in fifteen dogs. It has been used additionally for pelvic venography, hepatography and demonstration of vertebral venous pathways in another fifteen dogs. No serious complications developed.—*James J. McCort, M.D.*

El-Gholmy, A., Grace, H., Ragab, M., Nabawy, M., Gabr, Mamdouh, and Hashim, Neimat. Splenoportal venography in infancy and childhood. *J. Pediat.*, May, 1955, *46*, 506–519. (From: Pediatric Department, Kasr El-Ainy Faculty of Medicine, Cairo, Egypt.)

Forty-six serial portal venograms were obtained without complication on thirty-three children following the intrasplenic injection of 12-20 cc. of ioduron 30, 50 or 70 per cent. Injection was made under light general anesthesia. Two films were exposed just before completion of the injection, three others at one second intervals after injection and a sixth in 30 minutes. The patients fell into three categories: 8 normal, 17 with variable grades of liver cirrhosis (dietetic, bilharzial and postinfectious hepatitis) and 8 with variable grades of splenomegaly without cirrhosis (hemolytic anemia, Banti's syndrome and unknown cause).

Three successful splenoportal venograms in normal children showed a splenic vein of somewhat variable caliber and length, pursuing a straight course or at most showing a single gentle undulation. The portal vein also varied somewhat in size with a straight course at an angle of about 45 degrees with the midline. There was filling of the intrahepatic branches of the portal vein, the right filling faster than the left, but no splenic or portal collaterals filled. Dilution of the contrast material by superior mesenteric blood was evident at times, as was a small filling defect at the juncture of the superior mesenteric vein.

Abnormal venograms were arbitrarily graded 2

through 4. Dilatation and tortuosity of the splenic vein without filling of collaterals was established as grade 1. When splenic collaterals filled, it was considered grade 2, and grade 3 with filling of both splenic and portal collaterals. Failure of visualization of the hepatic veins with arrest of the contrast material in the portal or splenic vein and increased density of the collaterals was considered evidence of splenic or portal vein thrombosis and graded as 4.

Venography was successful in 15 of the 17 patients with liver cirrhosis. Two each were classed as grades 1 and 2, eight as grade 3 and two as grade 4. One was considered normal. Six successful venograms were obtained in the eight patients with splenomegaly, four showing variable degrees of dilatation and tortuosity of the splenic vein without filling of any collaterals (grade 1) while two revealed evidence of splenic vein thrombosis (grade 4.) The degree of dilatation and tortuosity of the splenic vein was in direct proportion to the size of the spleen.

It is concluded that splenoportography is of practical value in assessing the degree of portal hypertension, each succeeding grade inferring a higher portal pressure. It also provides a means of localizing the site of obstruction and gauging the size of the veins. Postoperatively it may be useful in demonstrating the status of a portocaval anastomosis.—*H. G. Peterson, Jr., M.D.*

General

Piatt, Arnold D. Some problems of rural radiology. *Radiology*, May, 1955, *64*, 738–741. (Address: Department of Radiology, Newark Hospital, Newark, Ohio.)

There are many small towns in this country which are not able to support a radiologist with his specialized knowledge. This deficiency can be corrected by the radiologists in the larger cities performing their radiologic services in the smaller towns on a part-time basis.

The author writes of the problems he has encountered in his eight years' experience of part time work in hospitals of smaller cities. Most of these hospitals are structurally old and the radiologic departments had poor facilities and equipment. This the radiologist can help remedy when new building programs are started.

Staffing of the department with qualified personnel is another big problem. This has been combatted by initiating and maintaining an approved school for x-ray technicians and selecting the trainees from the hospital areas in an attempt to ensure laboratory technicians.

Daily film interpretation is attempted and daily visits are made wherever possible. A new system of maintaining office reports and records has been set up. Active participation in the medical programs of the various hospitals has done much to improve the services and contributions of the radiologist to the general increased benefits to the patient. Financially, a percentage basis has proved quite satisfactory.

The acquiring of clinical data and information about the patients has at times been difficult and the technicians have had to be relied upon to obtain this. Radiation protection to personnel and patients always needs emphasis and improvement.—*Donald N. Dysart, M.D.*

Young, H. Herman, and Kunkel, Melvin G. Diagnosis, treatment and prognosis of roentgen ray injuries to dentists. *J. Am. Dent. A.*, July, 1955, *51*, 1–7. (From: Section of Orthopaedic Surgery, Mayo Clinic and Mayo Foundation, University of Minnesota, Rochester, Minn.)

This report concerns 140 physicians, 52 dentists, 1 osteopath and 1 physician's wife in whom roentgen ray dermatitis of the hands developed as a result of their occupational exposure. Of this group of 194 persons with chronic roentgen ray dermatitis of the hands, 61 or 31 per cent experienced malignant degeneration of the lesion.

The authors describe acute and chronic roentgen ray dermatitis and the subdivision of each group into first, second and third degree.

Most physicians received roentgen ray injuries from fluoroscopic manipulations without adequate protection. The dentists received their injuries by holding the films in the mouths of patients while making roentgenograms of the teeth, hence it was the index finger and the thumb of one or both hands that were most frequently involved.

The best treatment for chronic roentgen ray dermatitis is prevention. The patient must hold the film in his own mouth while the operator makes the exposure from behind a leaded partition.—*Frank J. Rigos, M.D.*

Spear, Lewis B. Need for precaution in dental roentgenography. *J. Am. Dent. A.*, July, 1955, *51*, 7–12. (Address: Professor of Radiology, Indiana University School of Dentistry, Indianapolis, Ind.)

The author investigated 20 general practitioners of dentistry in Indianapolis with a representative cross-section of clientele. He found that each dentist made roentgenograms of an average of 462 patients in 1953 with an average exposure by all dentists of 2772 times.

The author then investigated 4 different makes of roentgen-ray apparatus used in the radiodontic department at Indiana University. The apparatus was calibrated at 7 and 15 inch focal-skin distances and with and without 1 mm. aluminum filter. The meter readings at the 7 inch focal-skin distance were 10 milliamperes and 65 kilovolt peak and at the 15 focal-skin distance 15 milliamperes and 67 to 70 kilovolts peak.

It was found that the primary and secondary irradiation received by the patient and all personnel can be reduced by using an extended focal-skin distance, correct filtration, fast films, proper equipment without radiation leaks, careful technic and finally awareness of the dangers involved.—*Frank J. Rigos, M.D.*

Smith, Scott W. Protection in the use of dental roengenographic equipment. *J. Am. Dent. A.*, July, 1955, *51*, 12–18. (Address: Chief, Radiological Equipment Section, Radiation Physics Laboratory, National Bureau of Standards, Washington, D. C.)

There are three potential sources of roentgen ray exposure for the dentist and his technician: (1) the useful beam, (2) leakage radiation passing through the tube protective housing and (3) scattered radiation from the patient and other objects.

The useful beam should be made small either by a lead diaphragm or a cone. A filter of 1 mm. of aluminum should be added to the tube port. Protection from leakage radiation coming through the tube protective housing can be achieved by placing absorbing barriers in the path of the radiation or by increasing the distance between it and the individuals involved. These same factors will operate to protect the dental personnel from scattered radiation. The patient should hold the film and the number of roentgenograms should be limited to a minimum. Finally a monitoring survey should be done under the direction of a qualified person using suitable measuring devices.—*Frank J. Rigos, M.D.*

Stanford, R. W., and Vance, J. The quantity of radiation received by the reproductive organs of patients during routine diagnostic x-ray examinations. *Brit. J. Radiol.*, May, 1955, *28*, 266–273. (From: Physics Department, Guy's Hospital Medical School, and Diagnostic X-ray Department, Guy's Hospital, London, England.)

Any routine diagnostic roentgen examination results in a certain quantity of radiation reaching the reproductive organs of the patient. This is either from the direct roentgen beam or from scattered radiation. Although the possible genetic effects are impossible to assess as yet, the authors undertook a detailed investigation of the amounts of radiations received by the gonads of both men and women during various roentgen diagnostic procedures. They have critically evaluated the factors which tend to increase the exposure of the reproductive organs to radiation.

Males generally receive more radiation to the gonads through scatter than do females, although the converse is true when direct irradiation of the abdomen and pelvis or lower spine is done. For example, an intravenous pyelogram will result in about 1.3 r to the ovaries, whereas less than .5 r will reach the testicles. However in a chest study only .07 mr reaches the ovaries and yet .36 mr is delivered to the testicles.

The practical necessity for reducing as much direct irradiation to the pelvis as possible is well brought out. Careful control of the field area, use of small cones, and limiting the number of exposures are of prime importance. Using high kilovoltage technique, increasing focus film distance, and using filters in the primary beam appeared to have little effect upon reducing the roentgen dose received by the gonads. —*Arch H. Hall, M.D.*

RADIATION THERAPY

Galloway, Thomas C. Symposium on roentgen therapy in treatment of tonsillar disease. (From: Departments of Otolaryngology, Radiology and Pediatrics, Northwestern University Medical School, Chicago, Ill.) I. Tonsillectomy in relation to irradiation and acute poliomyelitis. *Quart. Bull.*, Northwestern Univ. M. School, 1955, *29*, 125–129.

The roentgen treatment of infected or hypertrophied tonsils, once widely used, fell into disrepute because of lack of standardization of technique and its use by untrained or unconscientious operators. However, it again is receiving consideration. The authors of this symposium report roentgen therapy to be 25 per cent effective in producing cessation of symptoms for which it has been used. The best explanation of the effect of irradiation on lymphoid tissue seems to be that by its destruction of infiltrating white cells, enzymes are freed and the result of inflammation hastened.

At present the following indications for treatment of infected tonsils or adenoids are fairly well agreed upon: (1) repeated severe infection; (2) persistent chronic or subacute infection with impaired general health; (3) recurring infection with acute otitis and conduction hearing loss; (4) obstruction with facial and palatal deformity; (5) focal infection—metastatic, toxic or allergic.

Surgery is much more likely to give definite and permanent relief in focal infection, in recurring tonsillitis and in otitis media. Although there is little evidence that permanent alteration in lymphoid tissue is produced by irradiation, it may be preferable in the following: in infants; where the general condition is poor; where there is a bleeding tendency; in scattered lymphoid recurrences; in the presence of allergy where surgery would be of questionable value; or in combination with surgery.—*Henry J. Teuffen, M.D.*

Hamann, Anna. II. Effect of irradiation on hypertrophic tonsils and adenoids. *Quart. Bull.*, Northwestern Univ. M. School, 1955, *29*, 130–133.

The two-fold effect of irradiation on hypertrophic tonsils and adenoids is that small amounts destroy lymphoid tissue, and hyperplastic lymphoid tissue is affected more than normal lymphoid tissue.

Acute and chronic inflammation clears with small amounts of irradiation and thus the stimulus for hyperplasia disappears. The original plan of using large doses to small areas has changed to using small doses to the entire pharyngeal area.

Roentgen rays of 200 kv. are directed at two lateral fields cross-firing at Waldeyer's ring. In marked hyperplasia 600 to 800 r is used and 50 per cent of this amount in pure inflammation.

There are several advantages of the irradiation. The concept that bulbar poliomyelitis is more frequent in the absence of tonsillar tissue justifies the preservation of this tissue as done by irradiation. Tonsils and adenoids plus other lymphoid tissue, such as that at orifices of eustachian tubes, are all affected by irradiation. Systemic diseases, acute infections and other lesions not amenable to surgery do not contraindicate irradiation. There is no treatment morbidity, no risk of hemorrhage and the patients can be treated in an ambulatory way.

There are some limitations to irradiation. Results are poor in pure hypertrophy without inflammation. Fibrosis diminishes the effect of irradiation, especially in patients over 16 years of age where they have had repeated infection although crypts and infection may clear completely. Irradiation has no direct bactericidal effect but indirectly has some effect by changing pH and producing some immunological changes. There are numerous reports of disappearance of nephritis, arthritis and occasionally endocarditis following irradiation.

There are some alleged disadvantages of irradiation. Whether irradiation or repeated infections contribute more to the fibrosis which gave difficulty in later surgery is hard to determine. The latent damage from irradiation is of real concern but hard to evaluate. With greater experience it is now possible to predict and prevent many of these changes.

The results of many studies regarding the value of irradiation are favorable. In evaluating this, one must study results after several years have elapsed following therapy. The study of Uhlmann, Rosenblum and Perlman who observed the children for 3 to 5 years fulfills the time requirement. The total improvement in their careful follow-up was 70 per cent. Most observers agree on two points: (1) That response is best in those under 5 years of age; and (2) that in patients with recurrent disease after tonsillectomy and adenoidectomy, the results are satisfactory.—*Kriss M. Kerr, M.D.*

Sauer, Louis. III. Irradiation of hypertrophic tonsils and adenoids in young children; a preliminary report on clinical results. *Quart. Bull.*, Northwestern Univ. M. School, 1955, *29*, 134–137.

The author reports on 168 patients treated with irradiation in an attempt to avoid the hazard of increased seasonal susceptibility to the bulbar type of poliomyelitis. This form of infection generally is agreed to occur in individuals who have undergone tonsilloadenoidectomy, even in the remote past.

A total dose of 700 r will result in decrease in size of tonsils and adenoids, but should not impair the protective function of these lymphoid tissues. Radiation has been successfully utilized in Europe for many years without harmful results. Three external treatments to each tonsillar region, a treatment semiweekly for 3 successive weeks, were used.

Indications for treatment were the same as those for surgery, including recurrent attacks of tonsillitis with cervical lymph adenitis, and hypertrophic adenoids with acute impairment of hearing.

Significant reductions in ear, nose and throat infections were recorded in the follow-up period which ranged from one to three years. Patients previously unimproved by surgery have responded favorably in some instances. On the other hand, surgery is not precluded, if it should be indicated at some later date in patients initially treated with irradiation. Poorest results were obtained with irradiation in the presence of abundant scar tissue.

No child treated with irradiation since 1950 is known to have contracted poliomyelitis.—*T. B. Efford, M.D.*

Simpson, C. L., Hempelmann, L. H., and Fuller, L. M. Neoplasia in children treated with x-rays in infancy for thymic enlargement. *Radiology*, June, 1955, *64*, 840–845. (From: Division of Experimental Radiology and Radiation Therapy, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.)

In order to evaluate the potential danger of neoplastic sequelae in children treated with irradiation for an enlarged thymus in infancy, the authors undertook a survey of the present health of 1,722 children so treated between 1926 and 1951. They were able to trace 1,400 of them (81 per cent); 1,795 untreated siblings were also studied and used as a control group.

Seventeen of the treated children traced have developed a malignancy (7 cases of leukemia and 6 of thyroid carcinoma), and 9 more have had a thyroid adenoma. Of the untreated siblings, five have had an unrelated malignancy, and only one child has had a thyroid adenoma. In addition, four of the treated group and none of the untreated children have developed osteochondroma of the upper extremity. The expected rate for cancer in the general population for the treated children is 2.6, and for the untreated group 2.7.

All of the cases of thyroid carcinoma and 6 of the 9 children who developed thyroid adenoma were

found to have received over 200 r to the skin over the thymic area. None of the untreated siblings or those who received less than 200 r developed thyroid carcinoma, and only one of the untreated group has had a thyroid adenoma. Three thyroid adenomas occurred in children who received an unknown amount of irradiation. There was no relationship between the dosage or form of treatment in the seven treated children who developed leukemia.

A major objection in this study is the absence of a proper control group of untreated infants with enlarged thymus glands. Also the figures for cancer incidence in the general population, which were used for comparison, are not trustworthy because of under-reporting and the different manner in which they are obtained. This may account for the fact that the incidence of cancer among the untreated siblings was high compared to the general population.

The study shows a significantly higher incidence of neoplasia following thymic irradiation in infancy, particularly leukemia and thyroid neoplasia. Some relationship between the form of treatment and thyroid carcinoma exists, but none could be demonstrated for leukemia, and it may be that these children are just more prone to develop leukemia. This possibility is being investigated.—*C. L. Stevenson, M.D.*

Chu, Florence C. H., Phillips, Ralph, Nickson, James J., and McPhee, J. G. Pneumonitis following radiation therapy of cancer of the breast by tangential technic. *Radiology*, May, 1955, *64*, 642–654. (From: Memorial Center for Cancer and Allied Diseases, New York, N. Y.)

The incidence of pulmonary changes following irradiation of carcinoma of the breast by direct portal technic varies from 22 to 60 per cent. Radiation pneumonitis cannot be arbitrarily divided into the acute (exudative) and chronic (fibrotic) stages. The one may merge imperceptibly into the other. Complete or partial resolution may occur both in the early and the later phases of the process.

The authors describe a three-field tangential technic by which a fairly homogenous tumor dose of 3,500 to 4,000 r (250 kv.) can be delivered in three and a half to four weeks, to the breast, chest wall, and axillary, supraclavicular and internal mammary lymph node areas. The tangential technic produces radiation pneumonitis in only 7 per cent of cases. With the same technic using supervoltage roentgen rays (1,000 kv.), tumor doses up to 6,000 r have been possible in 6 or 7 weeks, but the incidence of radiation pneumonitis increased to 25 per cent.

The authors' three-field tangential technic is as follows: Medial and lateral fields are tangential to the chest and cover this as well as the axilla, the internal mammary, the infraclavicular and part of the supraclavicular lymphatic areas. The average length of each tangential field is 26 cm., the width is 12 cm. The supraclavicular field has an average size of 14 by 17 cm. and is directed parallel to the sagittal plane of the body. Bolus bags are packed on the chest wall with all fields. The average daily skin dose is approximately 500 r and the tumor dose of 4,000 r is obtained by delivering a skin dose of 2,500 to 3,000 r to the supraclavicular field and 4,000 to 5,000 r to each of the medial and lateral tangential fields. The physical factors used in postoperative cases are 250 kv., 1.5 mm. Cu filtration, half-value layer of 2 mm. Cu. The inoperable and concurrent cases are treated the same as the postoperative cases except that 1,000 kv. (half-value layer of 3.4 mm. Pb) is preferred. The tumor dose ranges from 4,000 r in 4 weeks to 6,000 r in 7 weeks.

The authors' findings demonstrate that the frequency and the severity of radiation pneumonitis can be reduced by the use of the tangential technic. Symptoms of pneumonitis occurred in 4 per cent of those irradiated with a tangential technic at 250 kv. and in 8 per cent of those irradiated with a tangential technic at 1,000 kv.—*A. W. Sommer, M.D.*

RADIOISOTOPES

Rigler, Robert G., and Scanlon, Paul W. Radiation parotitis from radioactive iodine therapy. *Proc. Staff Meet., Mayo Clin.*, April 20, 1955, *30*, 149–153. (From: Section of Therapeutic Radiology, Mayo Clinic and Mayo Foundation for Medical Education and Research, Rochester, Minn.)

The authors describe the case of a myxedematous patient who developed bilateral parotitis following the oral administration of radioactive iodine. The patient was given several doses for a tracer study without evidence of parotitis, but when 150 millicuries of iodine 131 was administered to treat an osteolytic metastatic lesion, the patient developed bilateral parotitis within twelve hours. The parotitis responded to conservative therapy and subsided within forty-eight hours.

The high concentration of iodine in saliva and the myxedematous state of the patient are believed to be significant factors in the development of the acute condition. No unusual radioactivity could be detected with a Geiger counter over the parotid glands. The saliva was not collected and studied for iodine content.—*C. L. Hinkel, M.D.*

Schneider, Richard, C., Pantek, Henry, Freeman, David G., and Farris, Robert G. Radioactive phosphorus in the localization of the brain tumors. *J. Michigan M. Soc.*, April, 1955, *54*, 434–444. (From: Section of Neurosurgery, Department of Surgery, Uni-

versity of Michigan Hospital and Medical School, Ann Arbor, Michigan.)

The authors present a series of 50 cases in which radioactive phosphorus (P^{32}) was injected intravenously and then the surface and subcortical regions of the brain were checked with a Robinson-Selverstone probe to register radioactivity on a counting rate meter. The procedure depends on the greater uptake of the phosphorus by tumor tissue than normal brain.

Approximately 1 millicurie of P^{32} is injected two and one-half to twenty-four hours prior to operation. Following craniotomy and incision of the dura the probe is inserted into the brain in one or more areas and the variation in the number of clicks gives the surgeon an idea of the proximity of the tumor as tumors take up the P^{32} in greater quantities than normal brain tissue. Readings are taken on the surface and in normal areas. Sometimes, both I^{131} and P^{32} are used. In these cases it is advisable to wait at least a week after the I^{131} is used to inject the P^{32}.

Meningiomas and glioblastomas have a high uptake of the P^{32}. Neuroblastomas and ependymomas also have a relatively high uptake. Astrocytomas and pituitary chromophobe adenomas have a low uptake. For glioblastomas the count is best taken about four hours after the injection while a longer interval between the injection and count should be allowed with astrocytomas.

Of the 50 cases presented, intracranial neoplasm was correctly diagnosed in 46. In 1 case the tumor was inaccessible to probing, in 1 there was a cerebral thrombosis, 1 had a cerebral abscess and the fourth missed case was a false positive with no tumor found. In the latter case it was thought that the high count was due to touching the choroid plexus.—*Frank M. Windrow, M.D.*

HARMAN, J. B., DE V. HART, P. L., and LEDLIE, E. M. Treatment of polycythaemia with radioactive phosphorus. *Brit. M. J.*, April 16, 1955, *1*, 930–934. (From: Royal Marsden Hospital, London, S. W. 3, England.)

The authors review their experiences in the treatment of 48 cases of polycythaemia vera. Twenty-eight patients were given P^{32} intravenously in a split dose technique with a six to twelve week interval. The total dose ranged from 6 to 12 millicuries. Sixteen patients were given single treatments ranging from 4 to 7 millicuries. In the majority of cases, massive venesections were performed prior to treatment in the hope of preventing complications. The volume loss was replaced by intravenous dextran before giving P^{32}.

In 29 cases, the average remission was two years and 7 others followed for one year were doing well. Five patients were inadequately treated and 3 were lost to follow-up. Four patients are dead. One died of acute myeloid leukemia four years after being a successful remission from P^{32}; total dose of radioactive phosphorus given was 20 millicuries. Two patients died of myelosclerosis following good remission of one and two years respectively. The fourth patient died of a cerebral thrombosis.—*John P. Storaasli, M.D.*

MOORE, VINCENT, GAMBLE, DEAN, LIBBY, RAYMOND L., and GOODWIN, WILLARD E. Radioactive chronic phosphate in treatment of urological tumors. *J. Urol.*, Feb., 1955, *73*, 410–416. (From: Departments of Surgery, Urology and Radiology, University of California Medical Center, Los Angeles, Calif.)

One important objective of this study was to observe the biological effect of a standard dosage of interstitial irradiation per gram of tumor tissue. Few published data are available in this respect. Radioactive chromic phosphate, a pure beta emitter, was used in the treatment of carcinoma of the bladder and prostate. The dose given was 100 microcuries of P^{32} per gram of tumor and the total calculated dose amounted to 88,500 rep. The injection was made by means of a manually operated glass syringe with careful technique so as not to contaminate any portion of the bladder mucosa by the radioactive phosphorus. Subsequently, transurethral biopsies were made of isotope injection areas. These biopsies indicate that the dosage delivered by 100 microcuries of P^{32} per gram of tumor tissue is adequate to locally destroy some prostatic and bladder carcinomas. The patients showed marked decrease in bladder symptoms. All had gratifying relief from pain with diminution of hematuria and decreased bladder spasms. This is quite different from the effects of radiation therapy employing gamma rays where the customary reaction is one of increased symptomatology associated with radiation cystitis.

The second objective of the program was an evaluation of the distribution pattern of the injected isotope. This could best be determined by autopsy studies. Since the injected material has a maximum penetration of 8.0 mm. and an average penetration of 3.2 mm., it is obvious that uniform, even distribution is necessary. The authors feel that this cannot be accomplished by manual means and therefore steps are being taken to develop an electrically powered isotope injector which allows the surgeon to devote all of his attention to the injection sites.—*George W. Chamberlin, M.D.*

HEUWIESER, H., and HORST, W. Gezielte intrakavitäre Bestrahlung mit Radiothulium. (Aimed Intracavitary irradiation with radiothulium.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 513–518. (From: Strahleninstitut des Universitätskrankenhauses, Hamburg-Eppendorf, Germany.)

Intracavitary irradiation of the bladder has a distinct advantage over external deep roentgen therapy because it protects surrounding healthy tissues, especially the nearby ovaries and rectum. Its chief disadvantage, however, is development of a secondary cystitis. In order to avoid or to minimize damage to the intact mucosa the authors shield the radioactive substance in such manner that only the tumor and its immediate surroundings are in the field of irradiation. They find radiothulium best suited because it is small enough to be included in a capsule together with two small lead cylinders and it still provides a satisfactory depth dose of 50 per cent at a distance of 1 cm. from the mucosal surface, like the radioactive cobalt. The capsule is attached to the tip of a flexible metallic probe, which in turn is in a urethral balloon catheter.

For lesions of the dome of the bladder the thulium cylinder is placed on top of the protecting two lead cylinders. For lesions at the equator the thulium is between the two pieces of lead and for lesions at the base the lead pieces are on top of the thulium. Foils of copper or gold, 0.5 mm. thick, can be attached to the periphery of the capsule so that only a small window remains for irradiation. Two autoradiographs demonstrate the effectiveness of the protective shielding.—*Ernest Kraft, M.D.*

MISCELLANEOUS

Roach, John F., and Hilleboe, Herman E. Xeroradiography. *J.A.M.A.*, March 12, 1955, *157*, 899–901. (From: Albany Medical College and Albany Hospital (Dr. Roach); and Albany Medical College and New York State Department of Health (Dr. Hilleboe), Albany, N. Y.)

The attempt to plan an emergency radiological service for civil defense is a difficult problem because of the difficulties in the storage, transportation, and use of the films. The radiant energy of an atomic explosion or its residual radioactivity is extremely destructive to the photosensitive emulsion of any type of film. The use of fluoroscopy alone is discarded due to the inherent limitations of this method. The use of polaroid film is rejected since its restricted resolving power, plus its relatively high cost and short shelf life, limits its possible usefulness in emergency hospitals near the bombed area.

Xeroradiography makes use of one of a group of materials known as semiconductors. Selenium is one of these, and has seemed most satisfactory for this purpose. The xeroradiographic plate consists of a sheet of metal with a thin layer of selenium fused on one surface. After the selenium particles have been charged, exposure to roentgen rays will cause them to discharge into the metal base plate. It is readily apparent that placing an object between the roentgen tube and the charged selenium plate will affect the selenium particles in accordance with the amount of roentgen rays passing through the various densities of the interposed object. The remaining charged particles of selenium will be in the form of an electric image. This electric image becomes visible by spraying a fine powder of opposite charge on the surface of the selenium. The result is an etching-like image in black and white, which looks like a conventional roentgenogram. It is a rapid procedure, requiring less than two minutes to charge a plate, expose it, and spray it with powder. The powder may be removed with a brush, and the procedure repeated with the same plate as often as desired. A permanent record may be made by transferring the powdered image to paper by means of either an adhesive or an electrostatic technique. A complete description of the basic procedures and the underlying principles is given.

It seems quite possible that xeroradiography may have use in routine clinical roentgenography. The xeroradiogram provides an image in which, unlike conventional film, both the radiodense and radiolucent portions are shown. Thus, if one makes an exposure of the skull and neck in the lateral projection, such widely differing structures as the skin, subcutaneous fat, laryngeal structures, cervical vertebrae, mastoids, and calvaria all are seen with clarity. One feature of this technique, which leaves much to be desired, is the exposure time required. The present technique is just a little faster than for film in cardboard holders. Further studies are being made in an attempt to obtain a faster exposure technique, reducing the exposure time at least to that for films in cassettes with par-speed screens.—*D. S. Kellogg, M.D.*

Paatero, Y. V. Die Anwendung der Pantomographie für klinische Untersuchungen. (The application of pantomography for clinical examinations.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 525–528. (From: Roentgen Division of the Odontologic Institute of the University, Helsinki, Finland.)

Pantomography means laminagraphy of curved layers. When the roentgen beam passes through a small slit, only such layer of a rotating object is recorded which moves with the same linear speed and in the same direction as the roentgen film. The film in a curved cassette and the predetermined layer do not change their relative position during the roentgen exposure. As a result the curved layer will be recorded sharply while all other layers are smudged.

The method is best suited for jaw bones in which case the roentgen tube remains stationary while object and film are rotated simultaneously. A special apparatus, the "pantomograph," has been constructed by the author which contains an object

holder for immobilization of the patient's head and a holder for the curved cassette. During the exposure the stool on which the patient sits is rotated slowly with the aid of an electric motor. Movements of the object and of the cassette are synchronized.

The following disorders of the mandible clearly demonstrated by this method are illustrated in the article: (1) fracture, (2) follicular cyst, (3) adamantinoma, (4) necrosis of the alveolar ridge following radiation therapy for carcinoma of the tongue, and (5) chondrodystrophy.—*Ernest Kraft, M.D.*

BIMLER, R. Gleichzeitige Darstellung von Skelett und Weichteiloberfläche (Kombibild-Röntgenphotogramm). (Simultaneous demonstration of skeleton and soft tissue surface; combined roentgenphotograph.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 529–534. (From: Chirurgische und Urologische Abteilung und Röntgenabteilung des Allgemeinen Krankenhauses Barmbek in Hamburg, Hamburg, Germany.)

After numerous trials the author has succeeded in superimposing translucent photographs on roentgenograms. Immediately following an ordinary roentgen exposure a snapshot picture is taken with a photographic camera. The object must remain immobilized during the two procedures and the camera must be placed in such fashion that the focal spot of its lens system occupies the same position as the target of the roentgen tube, thereby having the same distance from the object. The longitudinal axis of the camera's light beam must coincide with the central beam of the roentgen ray.

The photographic process in the darkroom requires fifteen different steps, and for accurate technical details the original article should be consulted.

The composite photoroentgenography is of value in showing topographic relationship, also in the demonstration and more rapid recognition of pathologic conditions simultaneously at the skeleton and at the overlying soft tissues. These advantages suggest utilization of the "combipicture" in textbooks, anatomical tables and for medicolegal purposes.—*Ernest Kraft, M.D.*

SEEMANN, H. E., and SPLETTSTOSSER, H. R. The effect of kilovoltage and grid ratio on subject contrast in radiography. *Radiology*, April, 1955, *64*, 572–580. (From: Research Laboratories, Eastman Kodak Co., Rochester, N. Y.)

Subject contrast is the ratio of x-ray intensities between the parts of the x-ray image under consideration and is essentially independent of the method of measurement. By means of numerous graphs, the authors illustrate the effect of scattered radiation on the value of the subject contrast. Subject contrast was found to decrease with increasing kilovoltage, and increase with grid ratio. Considerable discussion is allotted to the choice of whether an 8:1 grid or a 16:1 grid should be used. Obviously in very heavy parts, the 16:1 grid removes more proportional secondary radiation and is desirable.

With increasing kilovoltage, subject contrast of bone substance decreases more rapidly than does subject contrast of tissue-like substances.

It is emphasized that further experimentation will be required to determine whether image definition is adversely affected by the use of the higher kilovoltages.—*E. E. Seedorf, M.D.*

FRIK, W., and BUCHHEIM, C. E. Die Herabsetzung der Patientendosis bei Durchleuchtungen. (Lowering the dose to the patient during fluoroscopy.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, April, 1955, *82*, 466–474. (Address: Dr. Frik, Gebbertstr. 109, Erlangen, Germany.)

Since the effect of radiation is cumulative, it is not enough to believe that the patient is protected adequately merely by the prevention of skin damage. That the dose to the patient can be diminished appreciably by increasing the filter was established almost thirty years ago. Many authors have shown that the quality of the fluoroscopic image does not suffer because of the added filtration.

In addition to patients, the authors used a phantom to simulate lung and stomach fluoroscopies. As standard conditions for the lung study, 55 kv., 3 ma. were used and for the stomach 80 kv., 3 ma., without additional filter. The roentgen tube had an inherent filter equivalent to 2 mm. Al. The size of the field was constant at 10 by 10 cm. A standard distance of 36 cm. target-skin was employed. It was found that raising the kv. above 90 lowered even more the dose to the patient, but that under similar illumination of the fluoroscopic screen, the details were less clear. The greatest dose diminution, around 60 per cent, without losing detail in lung as well as in stomach fluoroscopy was accomplished with 90 kv., and an additional filter of 4 mm. Al (total filter equivalent of 6 mm. Al). The volume dose received by the patient was also computed. Thus it was shown that by making the radiation harder and more homogeneous, the volume dose was diminished correspondingly. The quality of the spot film was not influenced appreciably by the additional filtration.

Scattered radiation in the room is increased by the use of 90 kv., 3 ma. and 6 mm. Al equivalent filtration. The use of protective clothing and a small field are important.—*Samuel Richman, M.D.*

Gärtner, H. Die biologische Wirksamkeit schneller Elektronen und ultraharter Röntgenstrahlen einer 15-MeV-Elektronenschleuder im Vergleich zu Röntgenstrahlen üblicher Härte (Untersucht an Gewebekulturen). I and II. Teilen. (The biologic effect of fast electrons and ultrahard roentgen rays from a 15 mev. betatron in comparison with conventional roentgen rays; investigated on tissue cultures.) *Strahlentherapie*, Feb., 1955, *96*, 201–227; 378–395. (From: Universitäts-Frauenklinik, Tübingen, Germany.)

Tissue cultures of fibroblasts from chicken hearts were exposed to various single doses of roentegen rays at 184 kv., ultrahard roentgen rays at 15.8 mev., and an electron beam at 10.2 mev. The primary and secondary effects at various times up to twenty-four hours were observed.

Measured by influence on frequency of mitosis, the effect of these three types of radiation tended to become equal as the size of the dose was increased; *i.e.*, larger doses of the ultrahard and electron radiation were relatively more effective than small doses (at lower levels conventional roentgen radiation was more effective).

Morphologic changes during mitosis were most manifest in the metaphase with the ultrahard and electron radiation; with conventional roentgen radiation such changes were manifest in all stages of mitosis and only slightly more frequently in the metaphase.

A qualitative difference was proven between conventional roentgen radiation and the two high energy radiations: whereas conventional roentgen radiation produced immediate cell damage and death in resting (non-dividing) cells, the high energy radiation damaged only dividing cells so that they died during or after cell division.

Qualitative differences between ultrahard roentgen radiation and the electron beam were not demonstrated. Quantitatively, in terms of frequency of mitotic division, the ultrahard roentgen radiation was slightly less effective, without apparent explanation.

On the basis of clinical experience with a 6 mev. electron beam and the findings of this investigation, the introduction of electron and ultrahard roentgen radiation into therapy of malignant tumors appears well justified.—*Henry G. Moehring, M.D.*

Hofmann, D., and Müller, K. Mitteilung über erweiterte Untersuchungen des biologischen Effektes ultrafraktionierter Bestrahlungen. (Additional investigations of the biologic effects of ultrafractionated irradiations.) *Strahlentherapie*, March, 1955, *96*, 403–407. (From: Strahlenbiologische Forschungsabteilung der Universitäts-Frauenklinik, Göttingen, Germany.)

Since the difference in biologic effectiveness of an electron beam as opposed to roentgen radiation could depend on the discontinuous character of the electron beam, these investigations were designed to test biologic effectiveness of various frequencies and durations of interruptions of radiation. A stroboscopic apparatus was used to yield interruptions of radiation so that frequency of impulses could be varied from 0.41 to 1,166 impulses per second, and the ratio of the duration of the *impulse* of radiation to the *interval* between impulses could be: 1:2.25, 1:4.7, 1:10.4, or 1:23. The duration of an impulse of radiation ranged from 1×10^{-1} to 2.6×10^{-4} seconds and that of the intervals between impulses from 2.3 to 5.8×10^{-4} seconds. The test objects were 1.5 and 4.5 hour-old eggs of *Drosophila melanogaster*. The source of radiation was 160 mg. of radium filtered with monel metal. The results of the experiments are detailed by graphs.

Continuous radiation with the same dose as attained with any of the interrupted methods was always more effective in killing the eggs than the interrupted radiation. The relationships of biologic effect to frequency of interruption and to the impulse:interval ratio were complex. The only common characteristic of the isodose curves plotted for each impulse:interval ratio (with frequency plotted against biologic effect) was that with 4.5 hour-old eggs each isodose curve showed a maximum peak of biologic effectiveness. The frequency of impulses at which these maxima occurred varied with the dose and with the impulse:interval ratio; i.e., no common denominator for biologic effectiveness was apparent from study of these curves.—*Henry G. Moehring, M.D.*

Peterson, O. S., Jr., Foley, J. C., and Mosher, R. F. Device for the control of radiation distribution in moving beam therapy. *Radiology*, March, 1955, *64*, 412–416. (Address: Dr. Peterson, University of Vermont College of Medicine, Burlington, Vt.)

Rotation therapy in the medium voltage range has not in the past given a completely satisfactory distribution of the radiation. This is because both the rotatory axis and the target axis distance are fixed. In order to improve this radiation distribution it has become apparent that variation of both the target-skin and target-tumor distance, together with variation of milliamperage or speed during the rotational cycle is desirable.

The authors describe a device whereby they can rotate the source of radiation through an irregular orbit, thereby continually varying the tumor or skin-target distance. Rather than varying the speed of rotation, the milliamperage supplied to the tube is

varied in order to maintain a constant intensity.

Since no satisfactory method of tumor dose calculation is available for this type of moving beam therapy, direct measurements in presdwood phantoms are necessary.

A conventional type of roentgen therapy tube stand is being used by the authors with certain structural modifications which permit the variable orbital movement. The apparatus is flexible and may be used to administer conventional fixed-source irradiation as well as moving beam therapy with straight-line and rotary motions of the tube head. The patient may be treated on an ordinary table or truck in a comfortable supine, prone or horizontal position.—*Donald N. Dysart, M.D.*

Sonnenblick, B. P. On some aspects of the problem of human radiation protection. *J. Newark Beth Israel Hosp.*, Jan., 1955, *6*, 31–42. (From: Newark College of Arts and Sciences, Rutgers University and Department of Laboratories, Newark Beth Israel Hospital, Newark, N. J.)

The effect of roentgen and gamma rays on human genetics is discussed in the light of the greater use of diagnostic and therapeutic radiology as well as increasing use of radiation in research and industry. This problem is compounded by the lack of training in radiation protection of the ever increasing number of nonradiologists using ionizing radiation. The hazards of excess radiation from fluoroscopic units and from dental units are specifically reported.

The roentgen output of a large number of unselected fluoroscopes in northern New Jersey was surveyed in 1951 and 1954. The findings indicate an ignorance of basic principles of radiation protection. In the first survey only 30 of 63 fluoroscopes had an output of under 20 roentgens per minute, with one in the range of 110 roentgens per minute. The second survey, including some of those of the first survey, found the roentgen output to be under 20 roentgens per minute in only 30 of 56. In addition, some of the physicians did not own protective gloves or aprons, many had their machines in narrow cubicles so that scatter was enhanced, and in several instances the central beam was not aligned with the fluoroscopic screen.

An investigation of fluoroscopic units used in examinations of children showed similar findings except that the dose was increased by the exposure of relatively larger portions of the bodies of infants than was true of adults. In addition, the internal organs received a higher proportion of the skin dose because of the small diameters. Some of the examiners reduced the amperage and voltage except when screen illumination was poor and they were busy. As most did not adapt their eyes to darkness the exception may well have been the rule.

A review of an article concerning the dose received from dental units, by Nolan and Patterson (*Radiology*, 1953, *61*, 625), is included. Three of 32 dental units surveyed delivered 113 roentgens, 238 roentgens and 315 roentgens to the face and neck area during complete examination of the mouth.

The author's conclusion that "admonitions are definitely in order" is more than justified.—*John F. Weigen, M.D.*

Teves, M. C. Image intensification; instrumental aspects. *Brit. J. Radiol.*, April, 1955, *28*, 216–217. (From: Philips Research Laboratories, N. V. Philips Gloeilampenfabrieken, Eindhoven, Netherlands.)

A short description and diagram are given of the image intensifier tube as it is now produced by the firm of Philips. Within a glass envelope a roentgen-ray screen with a Patterson D phosphor is mounted and in direct optical contact with this screen a thin, transparent, cesium-antimony photoelectric cathode is processed. Roentgen rays passing through the patient produce blue fluorescent light in the screen, which in turn produces photoelectrons with a density distribution linearly proportional to the original roentgen-ray pattern. These electrons are accelerated to 25 kv. and are concentrated and focused by a very simple electron optical system on a small viewing screen which is covered with an aluminum-backed layer of a silver activated zinc sulfide-selenide phosphor. The image is exact and nine times demagnified. The gain in brightness (due to acceleration of the photoelectrons and to their concentration) is between 1,000 and 2,000 times. Viewing of the final small image is by a monocular or a binocular microscope of suitable magnifying power. The image may also be photographed with a normal 35 mm. camera or 35 or 16 mm. cine-camera, although the grain of the 16 mm. fast film is too coarse for acceptable results.

Thickness of the roentgen-ray screen has been the main limiting factor and is now about 0.3 mm. The lines of a normal stationary Bucky grid can easily be observed, giving an idea of the resolving power of the tube. The use in photography of a photographic film with a steep slope, a gamma of about 3.0, permits the use of hard roentgen rays thus lowering the dose to the patient and yet producing negatives with a satisfactory contrast.

The author feels that the use of the intensifier tube as a photographic device shows promising results as compared with direct roentgen-ray photography at about an equal roentgen-ray dose to the patient and superior to screen photography. It makes cineradiography of quick movements in the body possible without endangering the patient.—*Chauncey N. Borman, M.D.*

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